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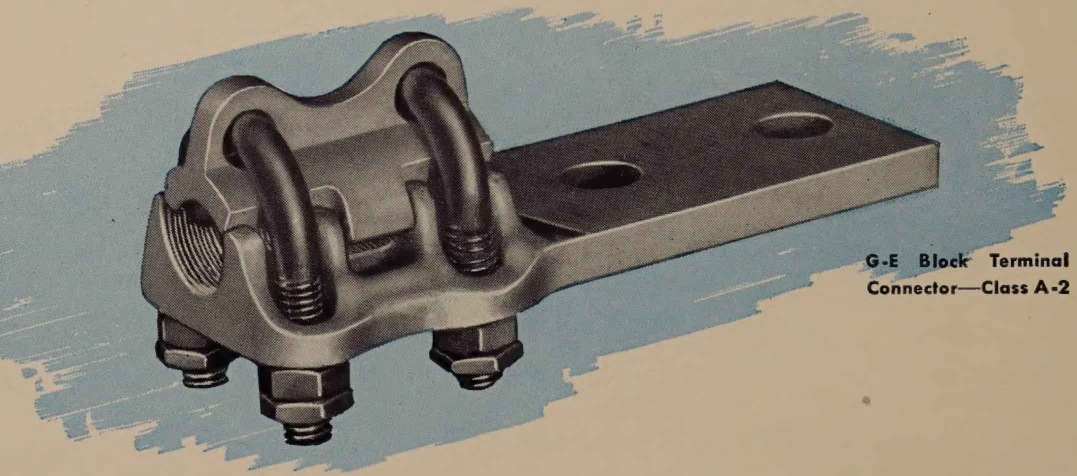
GENERAL ELECTRIC
Review

TABLE OF
CONTENTS
Page Three

August, 1949

This General Electric power connector can simplify your inventory by 63% to 83%



G-E Block Terminal Connector—Class A-2

Five General Electric power connectors of the type shown above will handle *all* the 22 conductor sizes listed in the table*. Compare this feature with other brands that usually *require a different connector for each conductor size.* You'll immediately realize how much G-E connectors can cut your stock costs by reducing the number of connectors required.

Here are other ways you can SAVE by using G-E connectors.

SAVE TIME—No more stock room safaris hunting for odd-size connectors. When you stock General Electric connectors, you stock fewer connectors. Also, you save time in ordering—you don't have to search through bulky catalogs looking for connectors that are seldom used and are a nuisance to order, besides taking up valuable stock space. G-E connectors are easy to order for the simple reason that you don't have to order so many varieties.

SAVE SPACE—Less stock room space required when you use G-E connectors because fewer connectors are needed to take care of the same range of conductor sizes that you're using now.

SAVE MONEY—When you use G-E connectors you reduce stock storage costs, and you save valuable time in ordering.

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SILVER CONTACT SURFACES are a *standard* feature on *all* G-E connectors for use with copper conductors—at no extra cost. This eliminates oxidation problems, assures lower contact losses and longer life.

SERRATED CONTACT SURFACES give extremely high pull-out strength and a permanent, high-conductivity joint that will resist vibration and give positive pressure on the cable at all times.

NON-CORRODIBLE HARDWARE is of high-strength bronze alloy that gives tight and trouble-free service. G-E connectors will not twist, distort, or season crack.

INTERLOCKING SIDES confine the strands of the cable within the conductor enclosure, thus obtaining full advantage of the cable's current-carrying capacity.

Place an order today with your G-E sales representative and start realizing the many benefits to be gained by using this new line of General Electric connectors. Also, write for a copy of bulletin GEC-400 that contains 38 pages of valuable information on these new connectors, and see for yourself how easy they are to order. Write to *Apparatus Department, Section G 856-51, General Electric Company, Schenectady 5, New York.*

*General Electric connectors come in a wide range of sizes and types—straight, tee, block, angle, parallel, expansion, ground, and many others. See bulletin GEC-400 for the complete line.

Conductor size	General Electric Catalog No.	Connector Mfg. A	Connector Mfg. B	Connector Mfg. C	Connector Mfg. D
1/0	6151174-9 One G-E connector replaces 6, stock is reduced 83⅓ %	√	√	√	√
2/0		√	√	√	√
3/0		√	√	√	√
4/0		√	√	√	√
250		√	√	√	√
300		√	√	√	√
350	6151174-59	√	√	√	√
400		√	None	√	None
500		√	√	√	√
600		None	None	√	√
½ IPS		√	None	√	√
700	6151174-88	None	None	√	None
750		None	None	√	√
800		None	None	√	√
1000		None	None	√	√
3/4 IPS		√	√	√	√
1250	6151174-118 One G-E connector replaces 3, stock is reduced 66⅔%	None	None	√	√
1500		None	None	√	√
1 IPS		None	None	√	√
1750	61151174-148	None	None	√	√
2000		None	None	√	√
1¼ IPS		None	None	None	√
Only 5 G-E connectors for *ALL* 22 conductor sizes		11 connectors for 11 cond. sizes. No connectors available for 11 conductor sizes	9 connectors for 9 cond. sizes. No connectors available for 11 conductor sizes	21 different connectors for 21 cond. sizes	20 different connectors for 20 cond. sizes

√ Indicates a different connector.

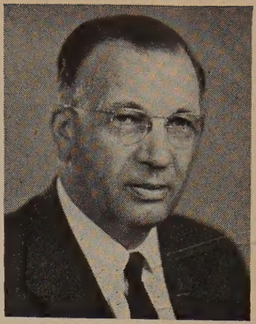
GENERAL ELECTRIC

856-51

GAS TURBINE-ELECTRIC LOCOMOTIVE

Highlights in the design, construction, and operation of this new locomotive, its 4500-hp gas turbine that is used as prime mover, and its electric generating and traction-motor equipment

By A. H. MOREY
Locomotive Engineering Division, Erie Works
General Electric Company



A H Morey

THE new Alco-GE locomotive (FIG. 1) which has recently completed preliminary road tests successfully is a freight locomotive designed to utilize the cheaper, heavy grades of fuel oil. It is powered by a gas turbine power plant and uses electric propulsion equipment similar to that employed on Alco-GE diesel-electric locomotives. A summary of principal dimensions and characteristics of the new locomotive is given in Table I.

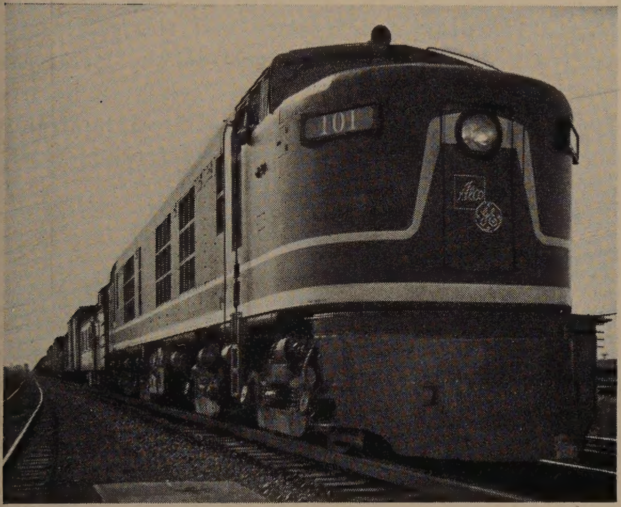


Fig. 1. The new 4500-hp gas turbine-electric locomotive, with train. During preliminary road tests, eighty-five loaded freight cars were hauled at speeds as high as 65 mph

The locomotive cab is divided into three compartments. An operating cab is located at each end of the locomotive to permit double-end operation. The center space between the two operating cabs is given over entirely to equipment. The general arrangement of these three cab compartments and the location of the major equipment is shown in FIG. 2. Cab and underframe are fabricated from structural shapes and sheets. High-strength steel is used in critical locations to reduce

TABLE I

PRINCIPAL DIMENSIONS AND CHARACTERISTICS

Wheel arrangement	B-B-B-B
Total weight	500,000 lb
Weight on drivers	500,000 lb
Number of driving axles	8
Weight per driving axle	62,500 lb
Driving wheel diameter	42 in.
Nominal rating	4500 hp
Continuous tractive effort	77,800 lb
Speed at continuous tractive effort	18.2 mph
Maximum speed	69 mph
Length over knuckles	83 ft 7½ in.
Total wheel base	68 ft 3 in.
Rigid wheel base	9 ft 4 in.
Width over cab sheets	10 ft
Width over grab handles	10 ft 7 in.
Height over-all	15 ft $4\frac{5}{16}$ in.
Height over roof sheets	14 ft 3½ in.
Number of traction motors	8
Gear ratio	4.1956
Air brake equipment	24 RL
Train control	US&S Composite
Number of air compressors	1
Displacement of air compressors	405 cfm
Electric braking	Braking resistor

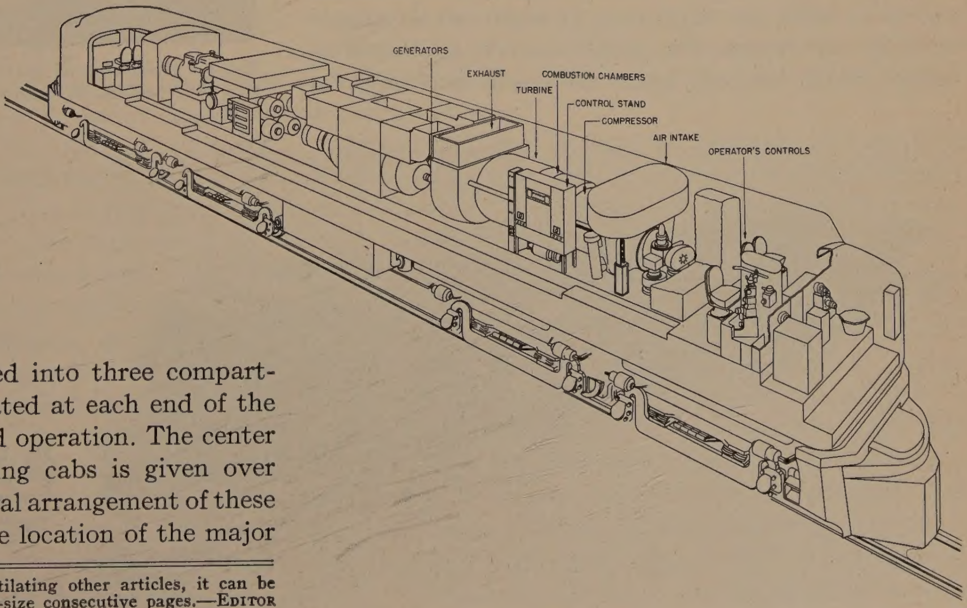


Fig. 2. Location of compartments and principal elements of power plant for gas turbine-electric locomotive

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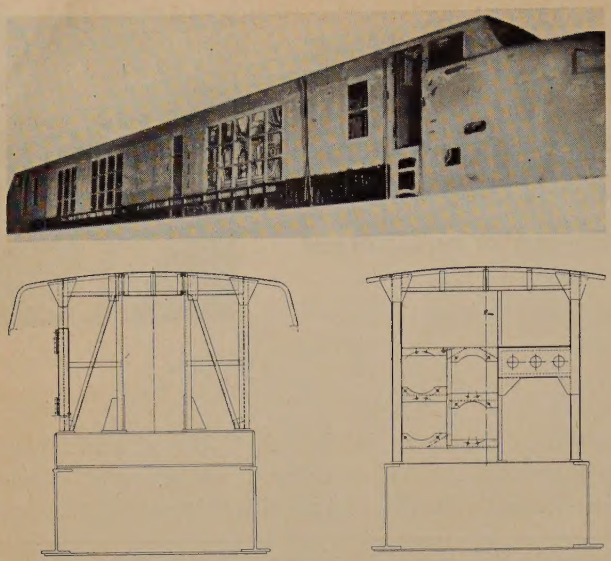

Fig. 3. General types of framework and construction employed in structure of locomotive

weight, and aluminum is used for covers and parts which do not require welding. The general type of construction is shown in Fig. 3.

The underframe consists primarily of two 33-in. I-beams, together with the necessary cross members, top and bottom plates, and baffles to form a rigid tank capable of carrying the main fuel supply. The superstructure is carried by vertical upright supports from the two I-beams. The roof and sides are supported entirely from this vertical structure. The sides are tied in at the bottom to the underframe structure and this tie provides the necessary aisle floors. The main support is through the vertical columns.

Fig. 3 also shows an outside view of the finished cab construction. Fig. 4 shows the bottom view of the underframe, with the fuel-heating coils in place, before installation of the bottom plate. Collision posts, built in the cab structure at each end, form the main members of the nose structure.

The cab is carried directly on two span bolsters which, in turn, are supported at each end by 2-axle swing bolster trucks. The span bolster is an alloy-steel casting which not only spans the trucks and supports the cab, but also forms an air duct for the traction-motor cooling air. Draft and buffing forces are taken directly through these bolsters to the center plate on the cab underframe and then through the underframe to the other span bolster. Traction-motor blowers located in the equipment cab near the locomotive center plates, discharge into the span bolster through flexible air connections. The design of this connection is unconventional in that all of the wearing parts can be replaced from inside the equipment cab without removing the cab from the span bolsters. The center plates are located on the span bolsters so that the weight is distributed uniformly on all axles until tractive effort is applied. Loading pads are provided to limit the tilt in the span bolster truck assembly when tractive force is applied. These serve to hold the weight distribution within quite close limits, even under extreme applications of tractive force and braking.

The trucks are of cast-steel construction. With minor modifications to the cab and underframe, 2-axle swing bolster trucks now used on many diesel-electric locomotives could be substituted for the present trucks on the gas-turbine electric locomotive. This should do much to facilitate maintenance and the stocking of spare truck assemblies. All trucks on the locomotive are interchangeable so that any truck may be used in any location in the running gear. Half of the running gear, illustrating the truck and span bolster assembly, is shown in Fig. 5.

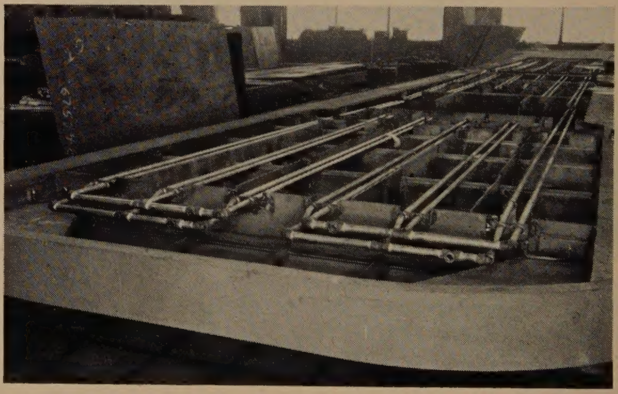

Fig. 4. Underframe of locomotive showing installation of fuel-heating coils and partitions in the space provided for the heavy oil storage

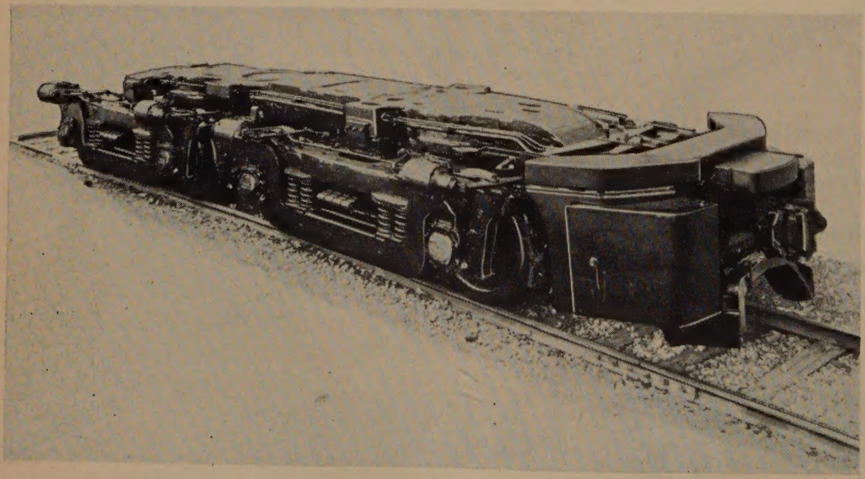

Fig. 5. Truck and span bolster assembly comprising one half of the running gear. This structure includes the air-duct system for cooling the traction motors

The power plant (FIG. 6) of the gas-turbine electric locomotive is a 4800-hp combustion gas turbine. Of in-line construction, it consists of a 15-stage axial-flow air compressor, six combustion chambers, and a two-stage turbine (FIG. 7). No regenerator or other heat-recovery equipment is used.

The principle of the gas turbine is to create hot, pressurized gases which take the place of steam in turning the turbine. Air under pressure and bunker C fuel oil are mixed and burned to make these gases. After being expanded through the turbine, the gases are exhausted to atmosphere.

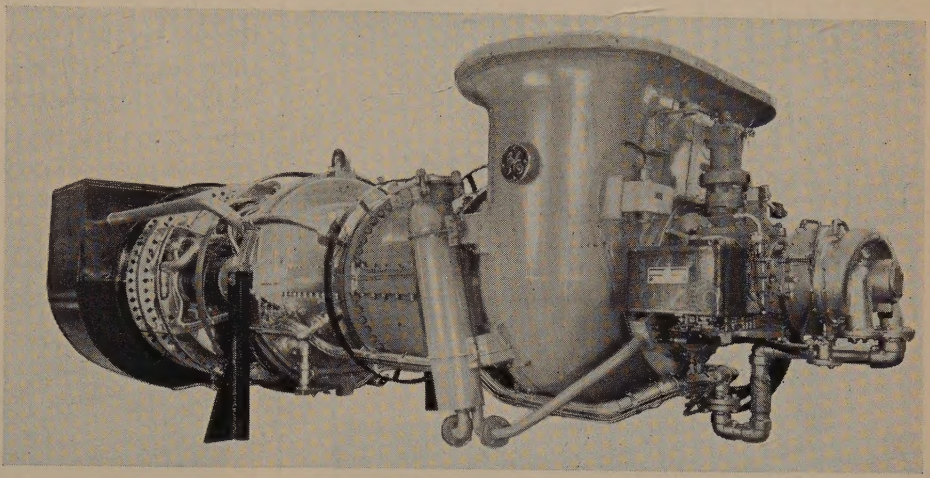

Fig. 6. Gas turbine power plant for locomotive, shown without lagging

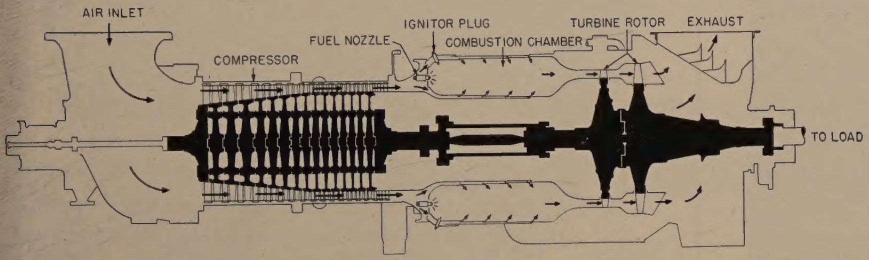

Fig. 7. Cross section of gas turbine together with flow diagram for air and gases in the new locomotive power plant

Spark plugs located in two of the combustion chambers ignite the pressurized air-fuel mixture. Cross ignition tubes, interconnecting all six chambers, fire the other four chambers. The resulting gases, at about 1400 F, attain a velocity of more than 700 mph and give the turbine a speed of 6700 rpm.

To start the power plant, a diesel-driven generator supplies power to one of the main traction generators which acts as a motor to bring the unit to firing speed. The ignition is turned on and diesel fuel is admitted to the nozzles. Power for the acceleration is taken both from the starting equipment and the unit itself up to 3500 rpm, when the starting supply is disconnected by means of reverse-current relays. The unit accelerates under its own power to idling speed, 4700 rpm, under governor control and is ready for load as soon as it is transferred to bunker C oil. All this takes less than four minutes.

In general, gas turbines have fewer parts and weigh less than other prime movers. Little auxiliary apparatus is required and maintenance problems are small. However, much development and research needs to be done before gas turbines, particularly for use in locomotives, can replace proved plants of other types.

Many problems may be answered after this first locomotive gas turbine power plant has operated in service. Major questions such as life expectancy, fuel consumption, variations in operation due to weather conditions, and many other considerations will be studied while the locomotive is in actual revenue service on the Union Pacific Railroad.

The power plant drives four traction generators through a single-reduction gear unit. The traction generators are of a new mechanical design operating at considerably higher speed than that of most diesel-electric locomotive generators. Two gears operate from a common pinion, driven by the power plant. Each gear drives two traction generators, one on each end of the gear shaft, connected to it through a flexible steel disk coupling. These four generators are entirely independent electrically, each having its own exciter and traction motors. The traction motors are of a type (GE-752) which is now in use on many diesel-electric locomotives.

Auxiliary power is supplied through an alternator driven from one of the traction-generator shafts and a d-c generator driven from another traction-generator shaft. These two machines supply all of the auxiliary power, both for the locomotive and the power plant. All of the auxiliaries are induction-motor-driven except those needed for starting the power plant. The a-c-driven auxiliaries include fuel pumps, lubricating oil pumps, radiator cooling fans, water circulating pumps, etc.

When not actually cranking the power plant, the small diesel engine-generator set used in starting operations is used to supply d-c power for auxiliaries and battery charging. When the power plant is in operation and the diesel-engine set is shut down, the d-c auxiliary

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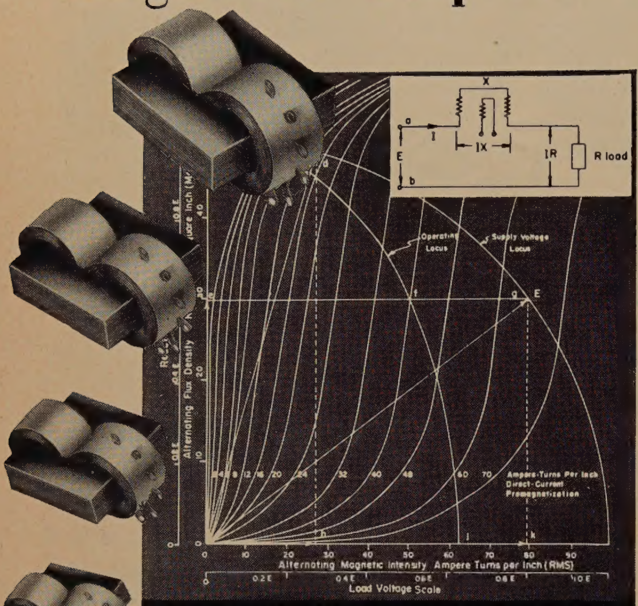

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GAS TURBINE-ELECTRIC LOCOMOTIVE

(Continued from preceding page)

load is taken by the auxiliary generator driven from the traction-generator shaft. When the power plant is shut down, the locomotive can be moved for hostling, etc., by connecting the diesel-driven generator across two of the traction motors.

Air for cooling the electric equipment and radiators, together with the air required for combustion, enters the cab through conventional-type air filters located in the sides. A total of approximately 147,000 cfm must be handled through these filters. Of this amount, 78,000 cfm is required for combustion. All of the hot air and exhaust gases from the locomotive are discharged vertically to minimize the recirculation of hot gases.

Handling large amounts of air through the sides of the locomotive means water entrainment in the air, consequently all wiring and bus bars are located in the eaves of the cab, higher than the air stream, and all piping is located below the floor.

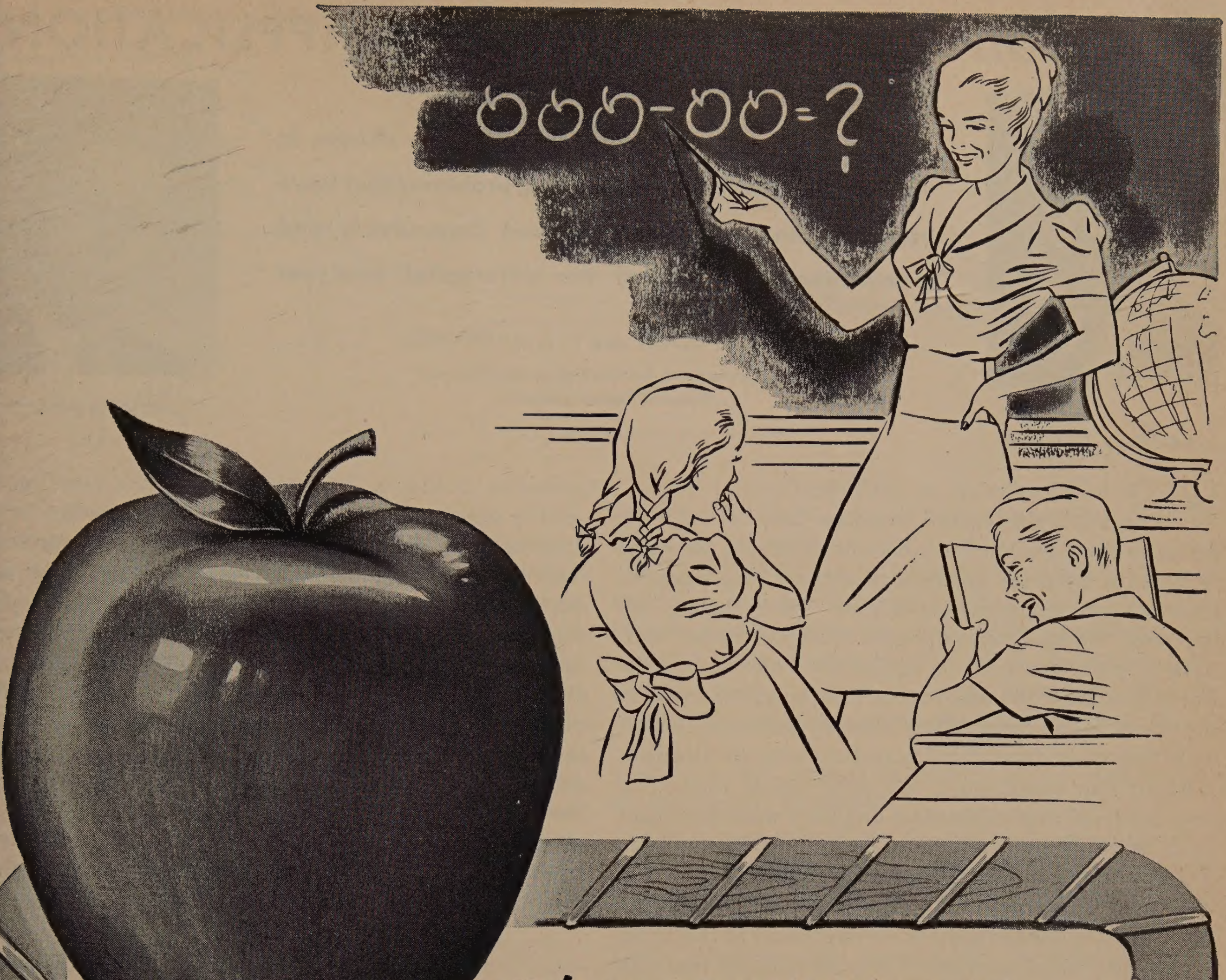
The use of heavy fuel oil requires considerable heating both for handling and for atomization. Fuel is held in the storage tanks at approximately 100 F and delivered to the fuel nozzle at approximately 220 F. This heat is supplied by a small-sized conventional train-heating steam generator. Since the locomotive is designed for freight service, no provision is made for train heating. This means that the boiler controls are simple and that exhaust steam can be collected and returned as condensate. Approximately 80 percent of the water required for heating is recovered as condensate. This makes unnecessary the storing and carrying of large amounts of water and should go far in reducing the maintenance on the steam generator.

The lubricating oil used in the power plant and reduction gear is cooled by water which, in turn, is cooled in a conventional radiator. The cooling requirements are much less than those on an equivalent diesel-electric locomotive. This made possible the installation of the radiators in the cab roof. These radiators are arranged to drain promptly, and it is not anticipated that the use of anti-freeze compound will be necessary.

The handling of the locomotive is essentially similar to that of diesel-electric locomotives.

The control is similar also, except that power-plant output of the new locomotive must be limited where necessary to keep the turbine temperature within proper limits.

A great deal of attention has been paid to accessibility for maintenance. The equipment is grouped in logical, easily-removable assemblies so that if it is necessary to remove any equipment the job can be done quickly and simply. Adequate room has been provided for necessary maintenance on the locomotive. The maintenance cost should be low for this locomotive compared with other types of motive power.



LET'S NOT DO CAPACITOR ARITHMETIC IN APPLES!

Remember the old story?

"Look, Ruthie," said the substitute teacher, "if you had 3 peaches and gave 2 to Johnny, how many peaches would you have left?"

Ruthie pondered.

"I don't know, teacher," she finally whispered. "When our regular teacher is here, we always do arithmetic in apples."

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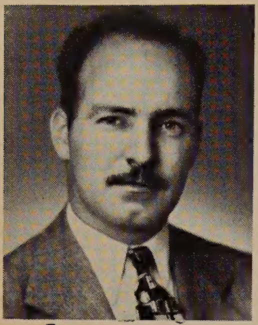

Arthur C Cook

Continued usefulness and versatility are shown in the newer varieties of engineering problems that have recently been set up and solved dependably and economically by use of the differential analyzer

By A. C. COOK and F. J. MAGINNISS
Application and Service Engineering Divisions
General Electric Company

SINCE its completion in 1943 the General Electric Company's differential analyzer has been set up for more than one hundred distinct problems. Many of these have been set up numerous times, the range of investigation being extended each time. During the late war, all analyzer problems were concerned with design or performance of equipment essential to the war effort. Now the analyzer is continuing to assist in the design of equipment, both military and nonmilitary, for ever-greater dependability and economy for the user.

About four years ago, a few applications which had been made of this differential analyzer were described in an article(1) by one of the present authors. Many of the more recently completed problems differ considerably from those previously reported; consequently, it seems worth while to report on some of these at this time.

The differential analyzer(2) is a mechanical machine used for the solution of a large variety of physical problems. It may be made to perform this function by setting up a mechanical analogy of the system being analyzed. Values of pertinent system variables are represented in magnitude and sign by the number and direction of rotations of a shaft. Integration is performed mechanically (aided by an electronic follow-up system); addition of shaft rotations is effected by differential gears; and multiplication by constants merely involves a gear ratio between shafts. Input functions to a problem may be fed into the analyzer by manual or automatic rotation of an input-table shaft, the number of rotations being made proportional to the magnitude of the ordinate of a curve plotted on the input table. Nonlinearities are easily introduced into a problem by integration (which is not limited to in-

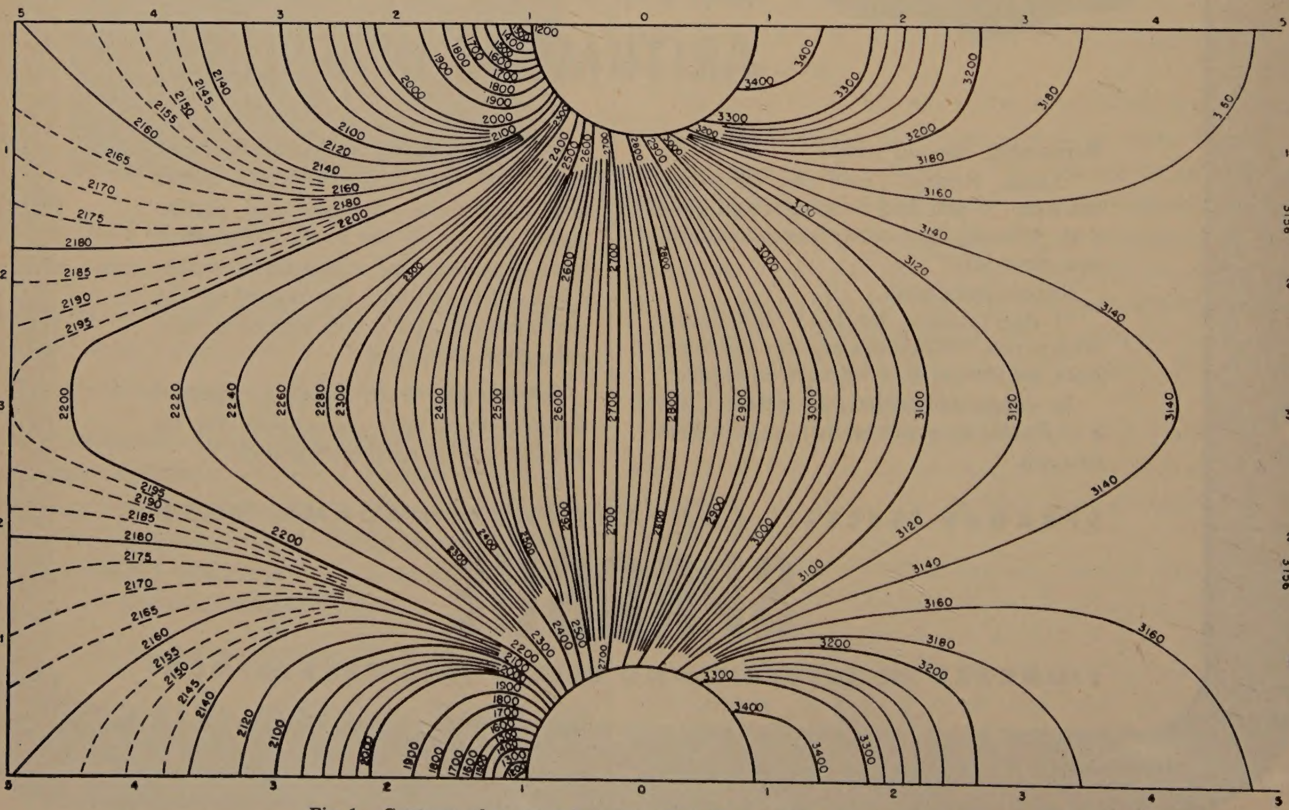

Fig. 1. Contours of constant E_y in interelectrode space in a vacuum tube

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(1) Numbered references are listed at the end of the article.

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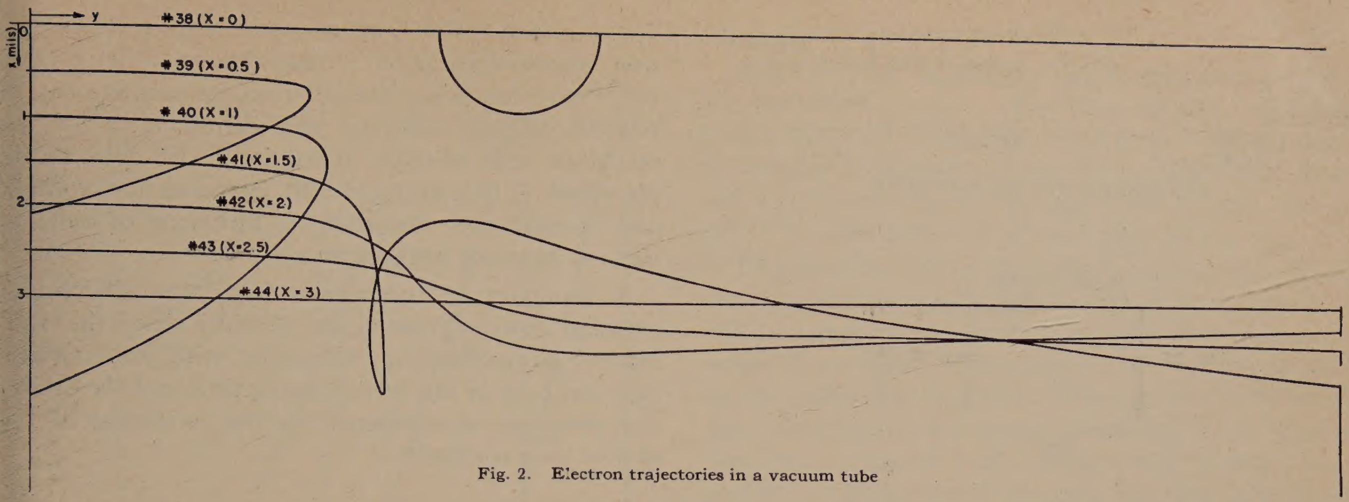


Fig. 2. Electron trajectories in a vacuum tube

dependent-variable integration) or by using input tables as described. Nonlinearities of a discontinuous type may be handled in the mechanical transmission and interconnection system of the analyzer or may again be taken care of by input-table functions. In addition to the ordinary input curve in the form of a single-valued function of one variable, the mechanical differential analyzer permits the inclusion of functions of more than one variable. This is illustrated in FIG. 1 (described later), in which the y component of the electric field strength in a vacuum tube is known as a function of both the x and y co-ordinates. Finally, the results are automatically plotted on an output table in the form of curves; any problem variable may be plotted either as a function of the independent variable or of any of the dependent variables. Thus mechanical integration, addition, multiplication etc. of variables are carried out by forming mechanical circuits which conform with the mathematical equations of the physical system being investigated.

ELECTRON BALLISTICS IN VACUUM TUBES(3)

The differential analyzer was used to determine the paths of electrons in an electrostatic field, for example in the interelectrode space in a triode oscillator and in a combined electrostatic and magnetic field as in the magnetron.

In the former case, contour lines of the x and y components of electric field strength were plotted in the interelectrode space for given potentials on grid and plate as shown in FIG. 1. In this plot the cathode is along the left border, the grid wires are the circles, one half of one being shown along the top, another half at the bottom, and the plate is off to the right. The region near the plate was omitted since the gradient is constant in this part of the tube. The differential equations satisfying Newton's and Coulomb's laws for the force on a charged particle in an electric field are solved, for an electron starting from the cathode, to give its position at all times. At any instant, the position (x, y) of the electron in the interelectrode space determines from curves similar to those in FIG. 1 the force acting on it and consequently its x and y components of acceleration. FIG. 2 shows typical electron trajectories for given conditions of amplitude and phase of the grid and plate potentials.

In the magnetron, a constant magnetic field was applied in a direction perpendicular to the plane of the electric field and electron trajectories. In addition, the effect of space charge was included in the electric field plots for the magnetron. A sample trajectory obtained on the differential analyzer is shown in FIG. 3.

LONG-DISTANCE POWER TRANSMISSION AS INFLUENCED BY EXCITATION SYSTEMS(4)

The system considered in this study is represented by a salient-pole generator with an elementary voltage regulator holding voltage at the high-voltage sending-end bus, a two-hundred-mile double-circuit transmission line with one intermediate switching station terminated by a large but not infinite system. The excitation system is represented by an exciter with a given ceiling excitation voltage and lower limit of negative excitation and an exciter-field time constant which was one of the variables of the study. The regulating system is represented by a regulator amplification factor which is the ratio of the increase in per unit exciter voltage to the per unit decrease in voltage

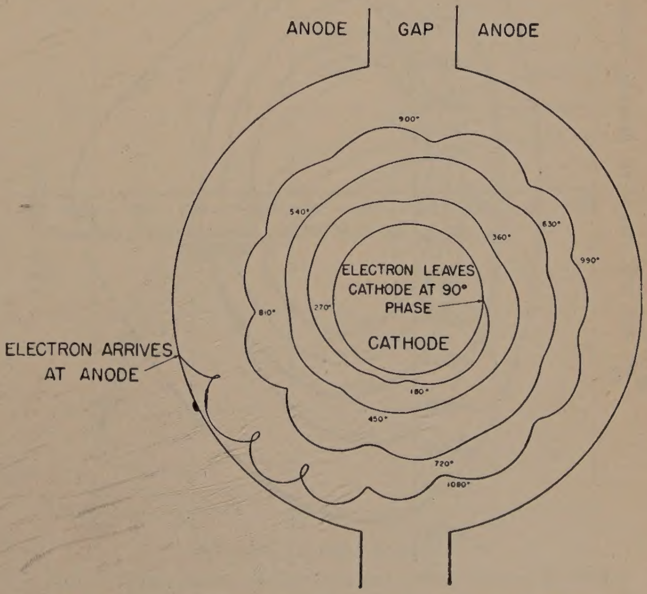


Fig. 3. Typical electron trajectory in a split-anode magnetron

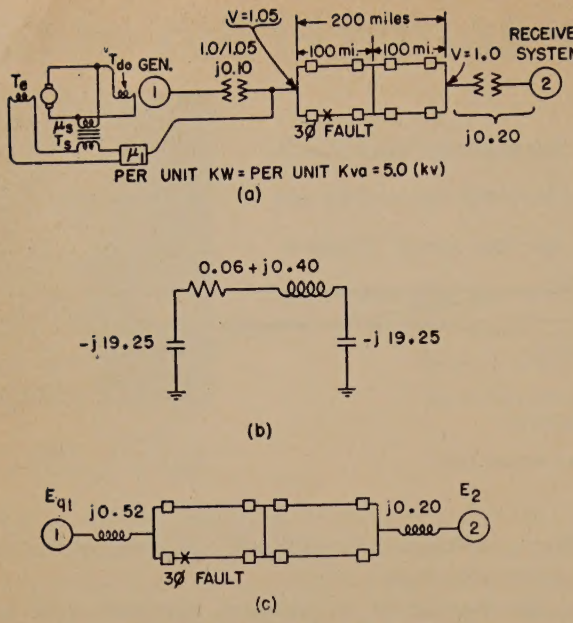


Fig. 4. A 200-mile transmission system

(a). System diagram
(b). Equivalent 100-mile line section
(c). System with equivalent terminal impedances

applied to the voltage-sensitive element of the regulator to produce this increase in exciter voltage. An excitation system stabilizer is represented by an amplification factor and a time constant. The system is shown in Fig. 4.

The equations of the system were set up on the differential analyzer; a fault was applied to one line at the sending-end bus, the fault was subsequently removed and the mechanical oscillations of the system thereafter were observed. Fig. 5(a) and 5(b) are typical plots of the relative angular velocity of the two machines vs. their relative angular displacement. In Fig. 5(a) the system appears to be settling down to a new steady-state angular displacement while in Fig. 5(b) the system is unstable after several oscillations; the relative angular velocity and displacement of the machines will increase indefinitely. In addition to plots such as Fig. 5(a) and 5(b), curves of flux, voltage, and current were recorded as functions of time at various locations in the system.

A summary of the results from this differential-analyzer study is given in Fig. 6, which shows the sending-end power that may be carried with stability as a function both of the fault-clearing time and the excitation response as measured by the reciprocal of the exciter time constant.

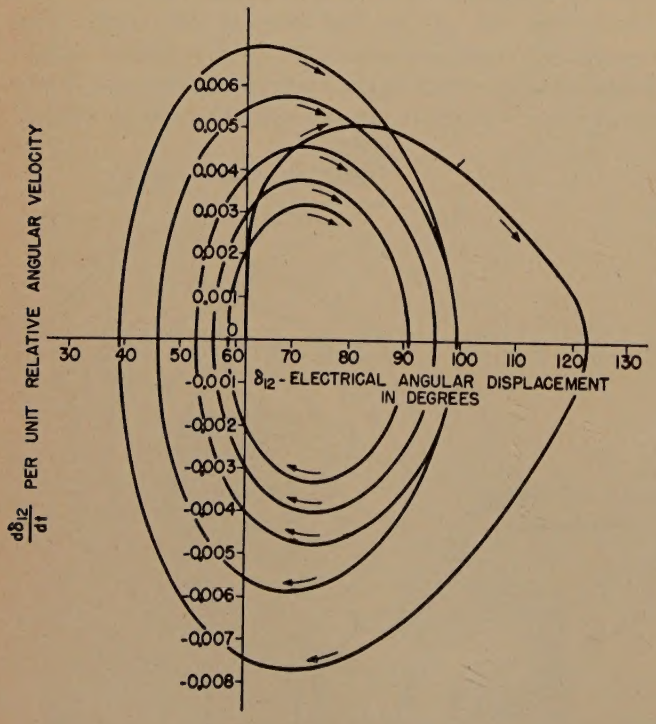
PRESSURE DISTRIBUTION IN A BEARING

Reynold's differential equation for the pressure in the oil film of a hydrodynamic bearing operating under steady conditions of load and speed does not take account of the variation in oil density with temperature. Recently in an attempt to explain the experimental fact that parallel-surface bearings will carry a finite load, this equation was rederived for a fluid of variable density.(5) A slider bearing of infinite width was considered, density was assumed to vary linearly with temperature, temperature was assumed to vary linearly with distance from the leading edge of the pad, and temperature variation of viscosity was neglected.

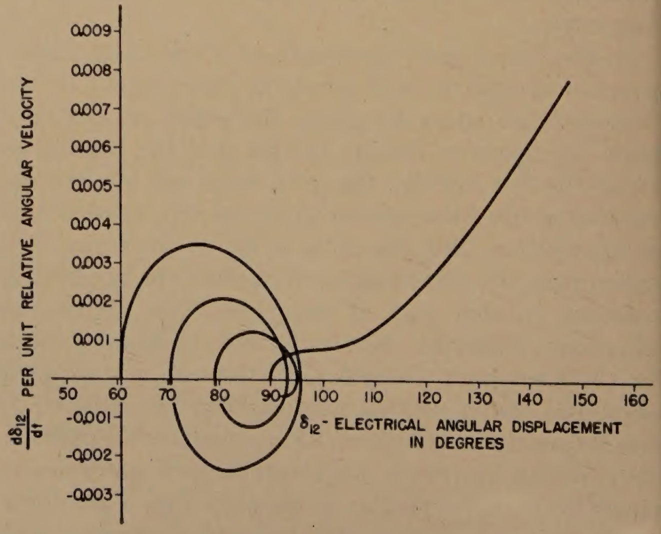
The differential analyzer has been used to extend this theory by (1) considering a similar infinite-width bearing in which the temperature distribution in the oil was not assumed to be a linear function of displacement but rather the proper local temperature was determined from conditions of energy balance, assuming no heat conduction through the metal surfaces, and (2) by applying this theory not only to parallel-surface but also to tilted-pad bearings. In addition, the

Fig. 5. Relative speed vs. relative angle of generator and infinite bus after fault removal

(a). A stable case
(b). An unstable case



(a)



(b)

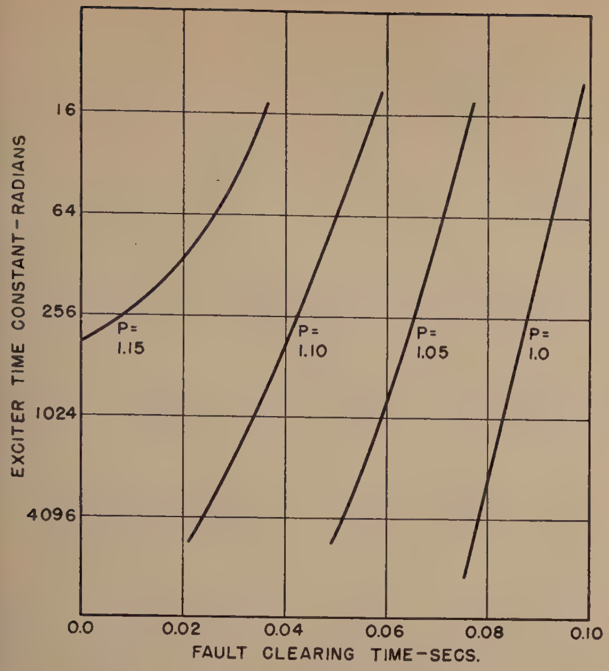


Fig. 6. Effect of exciter time constant and fault clearing time on ability of system to carry load

viscosity as determined by the local temperature was used. The plane surfaces of the bearing were assumed to remain plane under load in most runs. In a few cases, however, the clearance was assumed to depend on the local pressure.

Considering as a parameter h_1/h_2 the ratio of inlet to outlet clearance and for a minimum clearance of 0.002 in. (at the outlet edge) and an inlet temperature of 70 F, the pressure in pounds per square inch was plotted vs. distance along the bearing pad for a bearing of 25 in. length. Results are shown in FIG. 7. FIG. 8 shows the variation in temperature determined for the same four values of the ratio h_1/h_2 as in FIG. 7.

RESYNCHRONIZING OF GENERATORS(6)

It has become desirable to determine more accurately the conditions under which a generator may lose synchronism after a system disturbance. Consequently, it becomes of interest to know whether a generator may not synchronize spontaneously after a fault during which it has slipped one or more pole pairs.

To determine this, a round-rotor machine containing two amortisseur windings in each axis to represent as well as possible the solid-rotor eddy-current characteristics of a typical turbine generator was represented on the differential analyzer. This was connected to an equivalent system impedance terminated in an infinite bus. Stator currents and voltages, field current, rotor position and slip were observed subsequent to a three-phase fault at the generator terminals.

From the study, the effects of such factors as machine angle, load, system impedance, and generator inertia were determined. FIGS. 9(a) and 9(b) are analyzer curves which show the effect of system impedance on the ability of the generator to resynchronize from the most unfavorable angle. In FIG. 9(a), the low-impedance system, the average slip decreases each cycle until, on the third cycle of the rotor relative to synchronous speed after fault clearing, it goes through zero and the generator will apparently remain in step. With a high-impedance system, on the other hand, as shown in FIG. 9(b) the average value of the slip subsequent to the disturbance decreases for about five relative cycles without reaching zero; and thereafter it starts to increase again, indicating instability.

VARIABLE-RATIO FREQUENCY CHANGER(7)

The purpose of this study was to investigate the electrical performance of a variable-ratio frequency changer, shown schematically in FIG. 10, after the

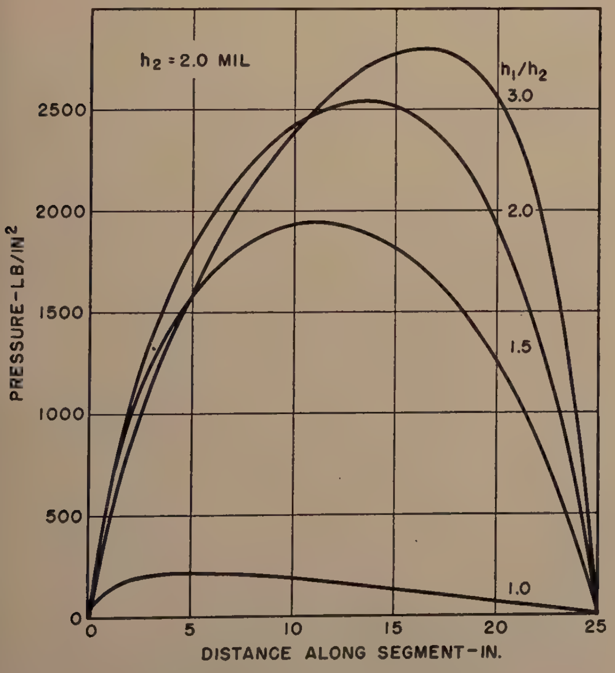


Fig. 7. Pressure distribution along a slider bearing of infinite width as affected by inlet-to-outlet clearance ratio

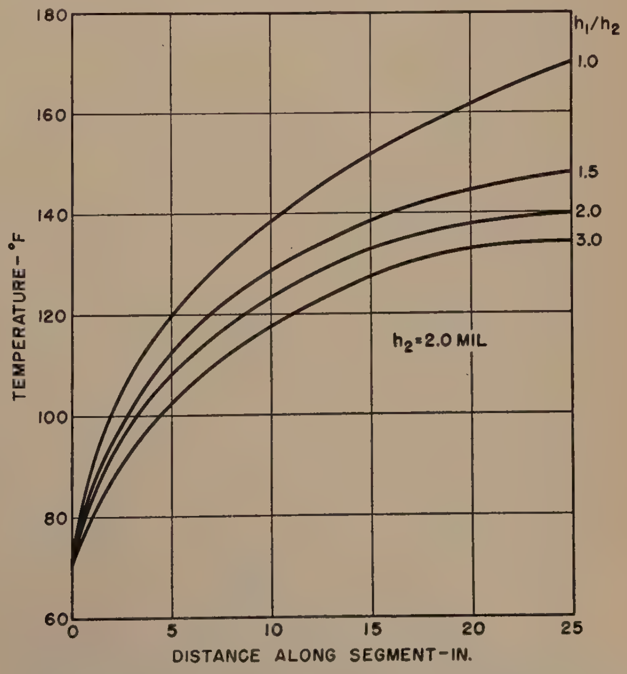


Fig. 8. Temperature distribution along a slider bearing of infinite width as affected by inlet-to-outlet clearance ratio

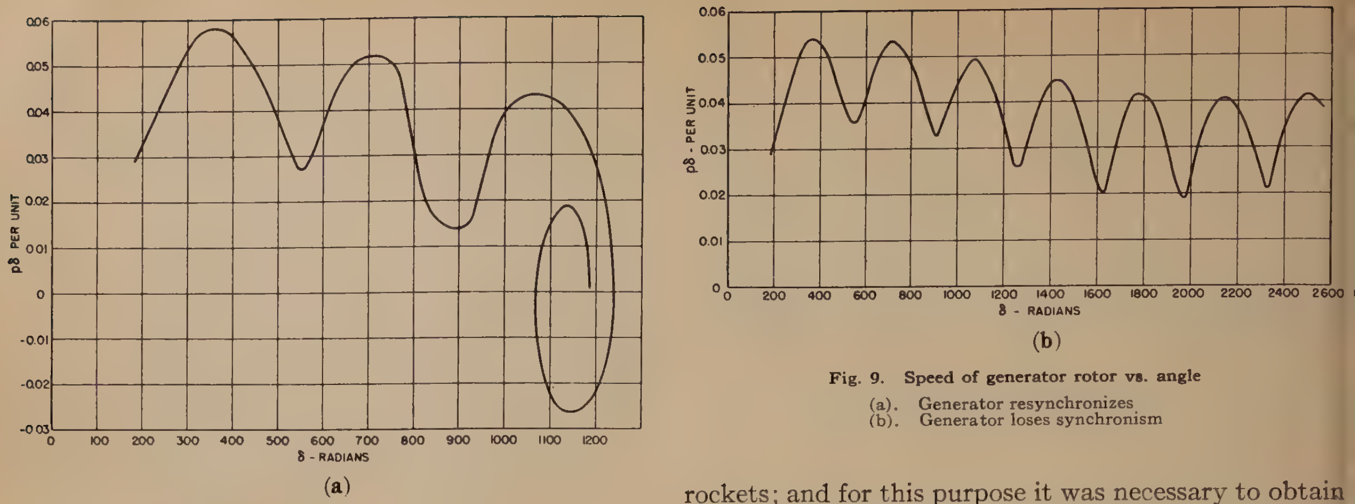


Fig. 9. Speed of generator rotor vs. angle

(a). Generator resynchronizes
(b). Generator loses synchronism

sudden application of load on the induction machine. The extreme case of short-circuiting the induction machine was included. Primary application of the results is as an aid in the selection of proper relaying equipment and settings and in the understanding of the performance of such relaying.

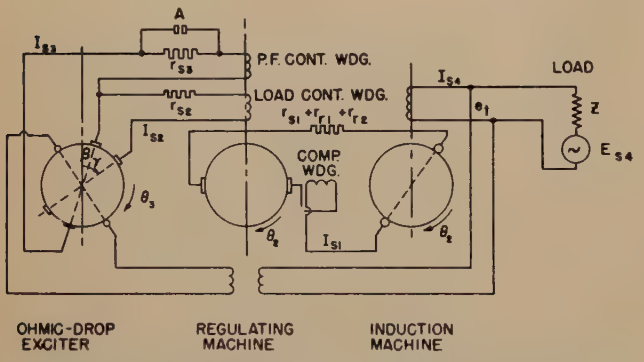


Fig. 10. Schematic diagram of circuit of variable-ratio frequency changer

The equations representing the system shown in FIG. 10 were set up on the differential analyzer, including the effect of magnetic saturation in the main induction-machine mutual flux path. With the machine running on open circuit, load was suddenly applied either three-phase or single-phase and the instantaneous load current was plotted. FIG. 11 is a summary of the results. This shows the rms value of the a-c component of load current vs. time for various suddenly applied loads The loads are specified by the external reactance, L_{ext} applied at the terminals. The limiting load beyond which terminal voltage will not be maintained is shown by the smallest value of L_{ext} for which the a-c component of load current is maintained. This is seen to be $L_{ext}=0.75$ for the conditions in FIG. 11, which corresponds to a 1.33 per unit kva loading.

GUIDED MISSILES

After the recent war, a number of captured German V-2 rockets were brought to this country. It was proposed that these rockets should be assembled and used for experiments at the White Sands Proving Grounds. The research program contemplated actual firing of the rockets; and for this purpose it was necessary to obtain accurate information for programming control angles and fuel burning.

The equations of motion for a self-propelled projectile were obtained from fundamental relationships governing the acceleration of a variable mass away from the earth's surface. The great height attained by the missile required that the gravitational influence be considered as variable and that the lift and drag effects be considered in the true nonlinear manner. Also the changing density of the atmosphere was a required feature in the solution of the equations.

These nonlinear features of the equations were easily represented on the differential analyzer, where input data of a nonlinear nature are introduced in curve form from the input tables or by manual control of the shafts.

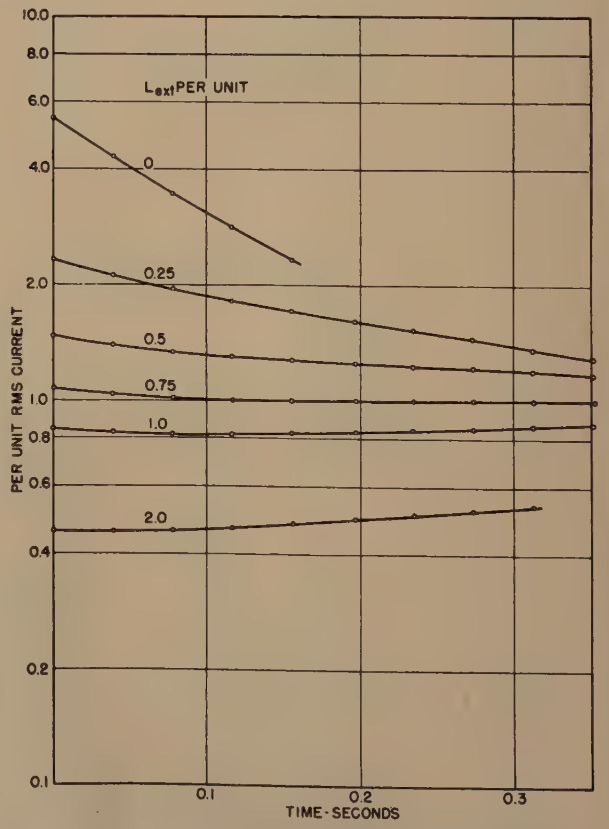


Fig. 11. Rms value of a-c component of load current vs. time, showing effect of external reactance for circuit shown in Fig. 10

Approximately one hundred trajectories were solved in the course of two weeks and the information thus obtained was a considerable factor in the successful firing of the rockets. FIG. 12 shows altitude as a function of time for a V-2 rocket for various pre-cutoff velocities. (Fuel is burned only during the initial part of the trajectory.)

DIFFERENTIAL BUS PROTECTION$^{(8, 9)}$

In differential bus protection there arises the problem of causing a relay to operate only for internal faults and not for external faults. This problem requires a thorough knowledge of the transient conditions prevailing in the current transformers which accompany the relay and a good quantitative picture of the differential-relay current under fault conditions. Hence, recent differential-analyzer investigations have been concerned with the transient behavior under fault conditions for current transformers connected differentially with a relay as the mutual burden. The use of the differential analyzer has permitted an accurate representation of the transformers, including saturation.

Information has been obtained for combinations of the following variables:

(1). Magnitude of fault current
(2). D-c time constant
(3). Transformer size constant
(4). Magnetic properties of transformer core
(5). Number of transformers connected differentially
(6). Ratio of load impedance to current-transformer secondary resistance

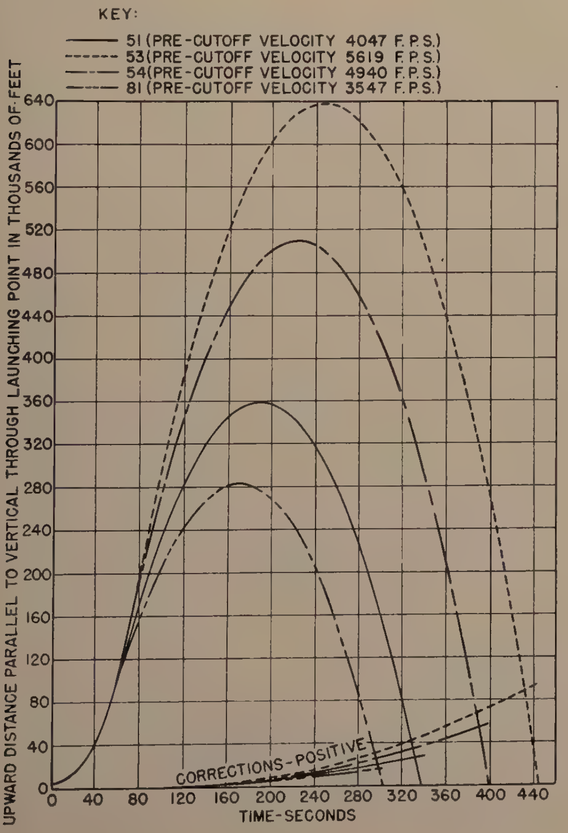


Fig. 12. Altitude of missile as affected by pre-cutoff velocity

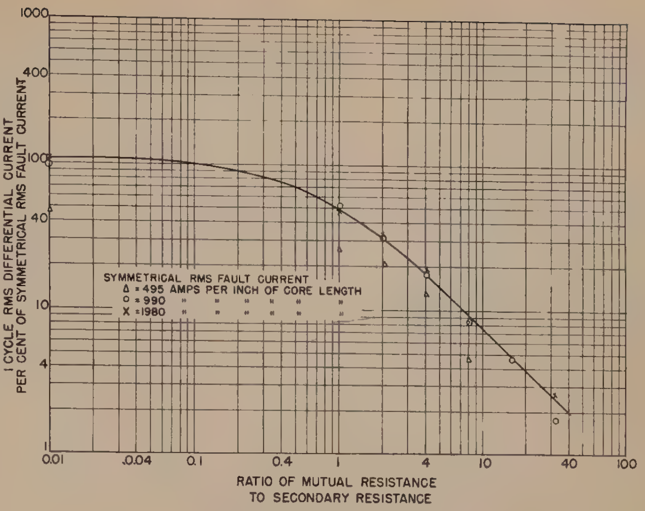


Fig. 13. Differential current for an external fault

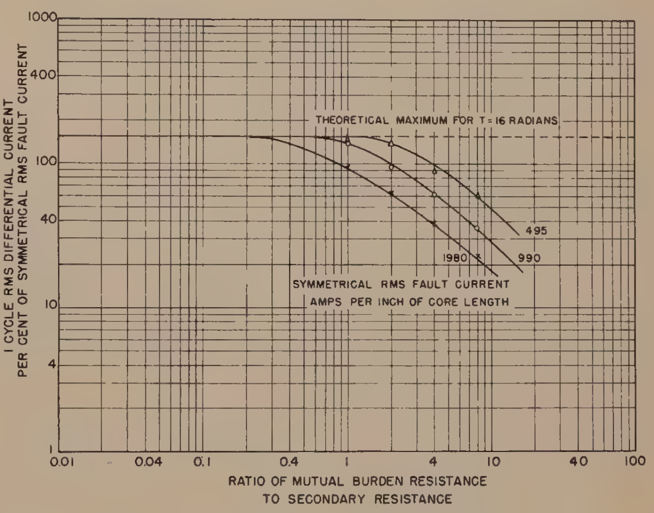


Fig. 14. Differential current for an internal fault

It has been concluded$^{(9)}$ that the differential current which flows when an external fault occurs can be kept small in magnitude by increasing the impedance of the mutual burden. Increasing the mutual impedance has considerably less effect on differential-error current for internal faults than for external faults. This allows a range of conditions where response can be improved by proper selection of the mutual impedance.

For an external fault the per cent differential current for a given combination of impedances does not depend on the magnitude of the fault current. This can be seen in FIG. 13, but the magnitude of the differential current does depend on the magnitude of the fault current, with an internal fault. This is shown in FIG. 14.

CONTROL PROBLEMS$^{(10)}$

In the successful design or operation of large machines, such as steam turbines, reciprocating engines, or even large generators, there arises a control problem. The control must maintain constant voltage or speed, or it must introduce a droop characteristic to divide load. With these large machines the control is a very important feature. The transient as well as the steady-

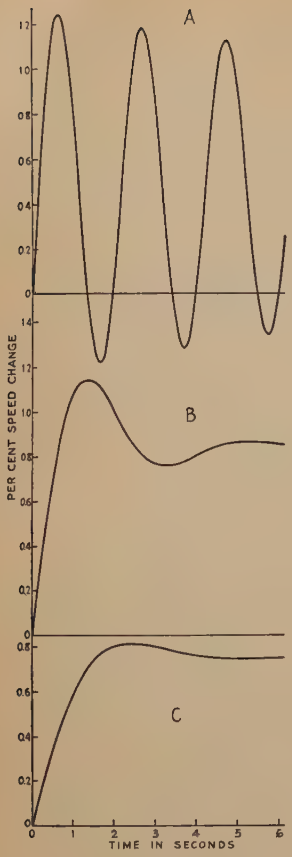


Fig. 15. Effect of regulation upon rates of decay of frequency disturbance

Curve *A*:
Regulation = 1.5 percent
Curve *B*:
Regulation = 6 percent
Curve *C*:
Regulation = 12 percent

state response of the system depends on the control system, and often the control system is complicated.

The differential analyzer has been a great aid in obtaining response data. The equations for the machine and for the control can be represented on the analyzer, and step function changes can be made in any of the parameters. It is usually speed, voltage, or fuel that is selected as a means of disturbing the system, and the response of pressures, air flows, currents, etc., as functions of time are plotted.

To change system constants such as inertia-storage volumes, time constants, or regulator amplification usually requires only a simple gear change. Hence a large range of combinations of these factors can be investigated in a short time.

Fig. 15 shows the effect of regulation in a prime mover. It shows that if the regulation is too broad the response is sluggish, but also that if the regulation is reduced too much the response is so sharp that instability occurs.

The effect of prime-mover inertia is similar in most cases. Reducing the inertia too far causes large oscillations and adding too much inertia causes the system to be sluggish. However, this generalization must be treated with caution, for it is possible to find a "best" value of inertia for many systems.

The effect of time lags in the system cannot be evaluated in general terms, and for the case of a large number of lags each combination must be represented in order that the true qualitative effect can be seen.

It has been common knowledge that the "deadband" type of insensitivity in a regulator or control prevents the control from bringing the system to steady state. Recently, however, a detailed study has been made of the effects of the "deadband" type of insensitivity. Fig. 16 shows the oscillations in a system and the lack of rapid decay which is attributable to deadband in the control. These investigations have been a factor in making it evident that an indication of their sensitivity should be included in specifications for control devices.

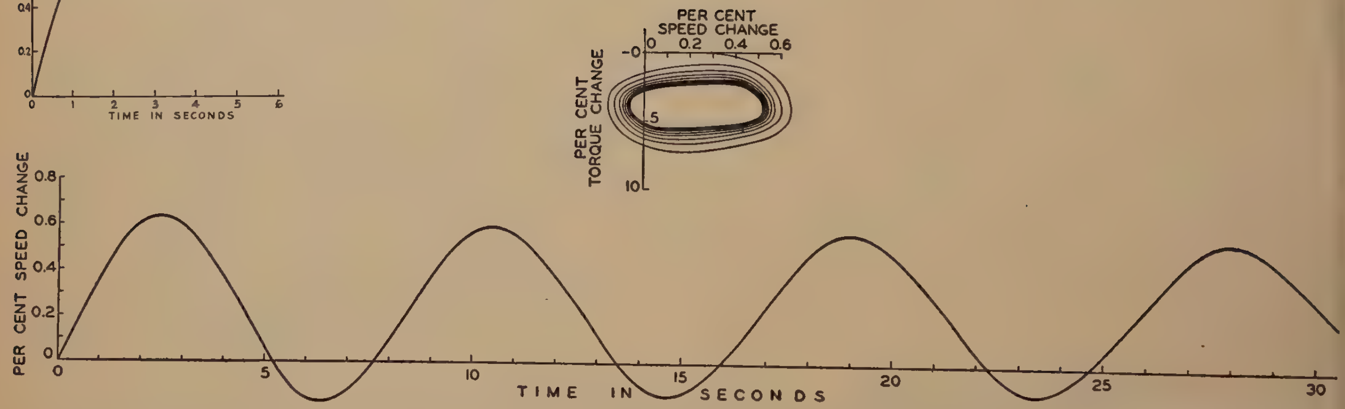


Fig. 16. Curves of frequency versus power input and frequency versus time. Such curves indicate the effect of dead band in producing sustained oscillations following a single load disturbance

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PULLING TENSION DURING CABLE INSTALLATION IN DUCTS OR PIPES

Computation of the magnitude of pull required, as affected by bends in the duct or conduit structure, provides a safeguard against damage to conductor or insulation by excessive tension

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Francis H. Buller

MANHOLES and splices have always been an important part of an underground cable system, regardless of whether the cable is drawn into a duct or into a pipe. They are, however, of the nature of a necessary evil; for they tend to add appreciably to the cost of an underground structure, and where underground conditions are congested it is often inconvenient to find a place to put the manhole.

At the present time the cost of manholes and the cost of making splices therein is unusually high. There is, therefore, a tendency on the part of operating engineers to demand the pulling of longer and longer cable lengths between manholes. This means that the tension applied to the cable during installation must be greatly increased; and it is important to be able to predict, with reasonable accuracy, what this tension will be, since excessive tension will result in damage to the cable finish, and possibly to the conductor and insulation as well.

Installation of cable in ducts: an operation that is aided by careful calculation of the tensions that will be required

For a number of years the following formula has been used to calculate the force required to pull a cable into a straight duct or pipe:

$$T = lwf \tag{1}$$

where

T = force in pounds required to pull the cable into the duct
l = length of the cable in feet
w = weight of the cable in pounds per foot
f = coefficient of friction between the cable and the duct or pipe

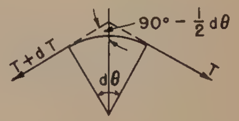


Fig. 1. Elementary segment of a cable bend, showing increments and direction of tension forces

It will be seen that this formula is a friction formula; it is assumed that the cable is being pulled at constant speed so that neither elasticity nor inertia come into the picture. Also, f is the coefficient of sliding friction rather than the coefficient of starting friction. The weight of the cable gives rise to a pressure between the cable and the duct, which, when multiplied by the friction coefficient, gives the frictional force to be overcome during the pulling operation.

Formula (1) does not take into account the effect of bends or of curvature of the duct or pipe. It is the purpose of this article to show how the effects of such bends can properly be allowed for.

When the cable goes around a bend, there is an additional force of friction brought into play. The tension on the cable (FIG. 1) causes it to ride up on the duct wall (FIG. 2a and 2c) and produces an additional pressure, over and above that caused by the cable weight, between the cable and the duct wall. This pressure materially increases the frictional force to be overcome when the cable is being pulled into the duct.

This article is so paged that, without mutilating other articles, it can be readily removed for filing as a group of full-size consecutive pages.—EDITOR

Bends may, of course, be either in the horizontal or the vertical plane. The equation for the effect of horizontal bends will be developed in detail, to show how the problem can be handled theoretically. By following the same methods, the equations given here without derivation for the effect of bends in the vertical plane can readily be derived if desired.

DERIVATION OF THE EQUATION FOR HORIZONTAL BENDS

Let the radius of the bend be r feet, and let it involve an angle of θ radians. Consider an element of angle $d\theta$ as shown in FIG. 1.

Resolving the forces acting on the cable as tension is applied, as shown in FIG. 1, gives the normal and tangential components which determine respectively the frictional force within the duct and the force that is effective in pulling in the cable.

$$\text{Normal component} = (T+dT)\sin \tfrac{1}{2}d\theta + T\sin\tfrac{1}{2}d\theta$$
$$= (2T+dT)\sin\tfrac{1}{2}d\theta$$

$$\text{Tangential component} = (T+dT)\cos\tfrac{1}{2}d\theta - T\cos\tfrac{1}{2}d\theta = dT\cos\tfrac{1}{2}d\theta$$

When $d\theta$ is small, $\sin\tfrac{1}{2}d\theta = \tfrac{1}{2}d\theta$ and $\cos\tfrac{1}{2}d\theta = 1$

so that

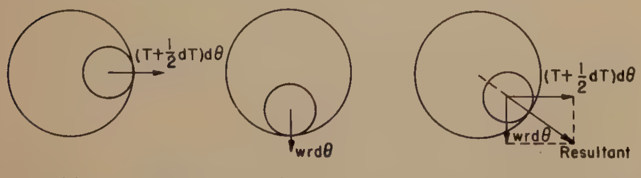
$$\text{Normal component} = (2T+dT)\,\tfrac{1}{2}d\theta$$
$$\text{Tangential component} = dT$$

and the frictional force is $f\,(T+\tfrac{1}{2}dT)\,d\theta$

If the cable were weightless, the tension would cause it to assume the position shown in FIG. 2a.

The cable would make contact with the duct at the level of its horizontal diameter. The force holding it there would be the normal component of the tensile force, $(T+\tfrac{1}{2}dT)\,d\theta$; the corresponding frictional force is $f\,(T+\tfrac{1}{2}dT)\,d\theta$.

If the cable were not under tension, its weight would hold it on the bottom of the duct. The force holding it there would be $wrd\theta$, and the corresponding frictional force would be $fwrd\theta$.



(a) (b) (c)

Fig. 2. Position of cable within duct as affected by weight and tension of cable

(a). Cable assumed weightless
(b). No tension, or straight pull
(c). Resultant of forces in cable being pulled in a duct bend

Since both the tension and the weight are acting simultaneously in any practical case, the condition shown in FIG. 2c gives the resultant force $\sqrt{(T+\tfrac{1}{2}\,dT)^2+(wr)^2}d\theta$. Neglecting second-order differentials, (that is, products of dT and $d\theta$), this reduces to $\sqrt{T^2+(wr)^2}d\theta$, and the corresponding frictional force is $f\,\sqrt{T^2+(wr)^2}d\theta$. This is equal to dT, the increase in tension in the angle $d\theta$; that is, $dT=f\sqrt{T^2+(wr)^2}d\theta$. If we write $x=\dfrac{T}{wr}$, the equation becomes

$$fd\theta=\frac{dx}{\sqrt{1+x^2}} \text{ and } f\int_0^\theta d\theta=\int_{T_1/wr}^{T_2/wr}\frac{dx}{\sqrt{1+x^2}}$$

which gives $f\theta=\sinh^{-1}\dfrac{T_2}{wr}-\sinh^{-1}\dfrac{T_1}{wr}$. (2)

Solving this equation for T_2 we get

$$\frac{T_2}{T_1}=\frac{wr}{T_1}\left[\sinh\left(f\theta+\sinh^{-1}\frac{T_1}{wr}\right)\right] \qquad (3)$$

For convenience in use, this equation is plotted in FIG. 3.

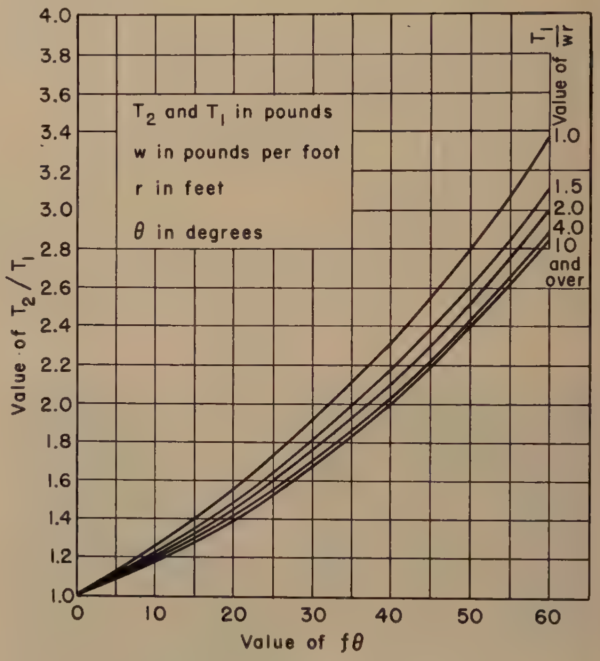


Fig. 3. Values of T_2/T_1 for application of tension formulas

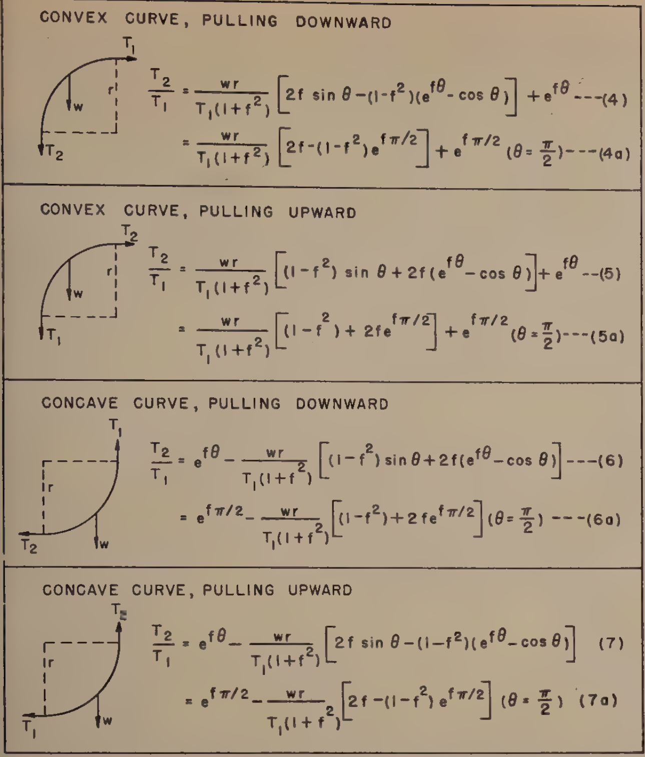
VERTICAL BENDS

The equations for vertical bends will be given below without proof. There are four possibilities with vertical bends: convex curves (where the cable bears against the bottom of the duct); concave curves (where the cable bears against the top of duct); and, of course, in either case, the pull may be either upward or downward. The equations are shown in FIG. 4.

When the equations for concave bends give negative results, it means that T_1 is too small to prevent the weight of the cable from pulling it out of contact with the duct wall. Under such conditions, the equations do not hold and $T_2-T_1=r\theta wf$, approximately.

VERTICAL RISERS

When the cable is pulled vertically through a riser, frictional forces will usually be negligibly small. However, the weight of the cable hanging in the riser wh (where h is the height of the riser) must be taken into



CONVEX CURVE, PULLING DOWNWARD

$$\frac{T_2}{T_1}=\frac{wr}{T_1(1+f^2)}\left[2f\sin\theta-(1-f^2)(e^{f\theta}-\cos\theta)\right]+e^{f\theta}\text{---}(4)$$

$$=\frac{wr}{T_1(1+f^2)}\left[2f-(1-f^2)e^{f\pi/2}\right]+e^{f\pi/2}\left(\theta=\frac{\pi}{2}\right)\text{---}(4a)$$

CONVEX CURVE, PULLING UPWARD

$$\frac{T_2}{T_1}=\frac{wr}{T_1(1+f^2)}\left[(1-f^2)\sin\theta+2f(e^{f\theta}-\cos\theta)\right]+e^{f\theta}\text{--}(5)$$

$$=\frac{wr}{T_1(1+f^2)}\left[(1-f^2)+2fe^{f\pi/2}\right]+e^{f\pi/2}\left(\theta=\frac{\pi}{2}\right)\text{---}(5a)$$

CONCAVE CURVE, PULLING DOWNWARD

$$\frac{T_2}{T_1}=e^{f\theta}-\frac{wr}{T_1(1+f^2)}\left[(1-f^2)\sin\theta+2f(e^{f\theta}-\cos\theta)\right]\text{---}(6)$$

$$=e^{f\pi/2}-\frac{wr}{T_1(1+f^2)}\left[(1-f^2)+2fe^{f\pi/2}\right]\left(\theta=\frac{\pi}{2}\right)\text{---}(6a)$$

CONCAVE CURVE, PULLING UPWARD

$$\frac{T_2}{T_1}=e^{f\theta}-\frac{wr}{T_1(1+f^2)}\left[2f\sin\theta-(1-f^2)(e^{f\theta}-\cos\theta)\right]\quad(7)$$

$$=e^{f\pi/2}-\frac{wr}{T_1(1+f^2)}\left[2f-(1-f^2)e^{f\pi/2}\right]\left(\theta=\frac{\pi}{2}\right)\quad(7a)$$

Fig. 4. **Equations applying to vertical bends of duct. Note that in the second equation in each case $\theta=\pi/2$**

account. It is added directly to the pulling tension if the pull is upward, and subtracted if it is downward.

NUMERICAL EXAMPLE

To illustrate how these formulas are used, take the case of a long station jumper, with a riser at one end, and a 45-deg bend in the middle. Assume the following conditions:

(a). A vertical concave bend, where the duct enters the ground, $\theta=90°$ $r=10$ ft

(b). 500 ft of straight cable in duct

(c). A horizontal bend, $\theta=45°$ $r=50$ ft

(d). 500 ft of straight cable in duct

(e). A vertical concave bend where the cable leaves the ground, $\theta=90°$ $r=10$ ft

(f). A vertical riser, $h=50$ ft

(g). Assume $w=10$ lb per foot of cable, and $f=0.4$

The calculation is as follows:

(a). There is very little if any tension on the cable as it enters the bend under condition (a). If the cable is fed in properly, the effect of this bend is negligible.

(b). 500 ft of straight cable.
$T=500\times10\times0.4=2000$ lb from Formula (1).

(c). 45-deg horizontal bend.

$$\frac{T_2}{T_1}=\frac{10\times50}{2000}\left[\sinh\left(\frac{0.4\pi}{4}+\sinh^{-1}\frac{2000}{10\times50}\right)\right]$$

from Formula (3).

$$\frac{T_2}{T_1}=1.38 \qquad T_2=1.38\times2000=2760\text{ lb}$$

(The value of $\frac{T_2}{T_1}$ could have been obtained from Fig. 3.)

(d). 500 ft of straight cable. $T=500\times10\times0.4+2760$ $=2000+2760=4760$ lb

(e). Vertical bend, pull upward, Formula (7a)

$$\frac{T_2}{T_1}=e^{0.2\pi}-\frac{10\times10}{4760\ (1+0.4^2)}[2\times0.4-(1-0.4^2)e^{0.2\pi}]$$

$$\frac{T_2}{T_1}=1.888 \qquad T_2=1.888\times4760=8990\text{ lb}$$

(f). Vertical riser. $wh=10\times50=500$ lb
$T=8990+500=9490$ lb

This is a very heavy pull for a cable of this weight, and it might be necessary to redesign the run, say with a larger radius of vertical bend, or a manhole in the run to reduce the pull to manageable proportions.

This calculation brings out the following points:

(1). A vertical bend at the trailing end, into which the cable can be fed, is not troublesome.

(2). A 45-deg bend of large radius in the middle of the run contributes materially to the friction, but is not necessarily impractical.

(3). A short radius bend of 90 deg at the pulling end is a very serious matter; and it makes little difference whether it is in the horizontal or vertical plane. In some cases it may be necessary to install a manhole at or near this bend to eliminate its ill effect.

SIGMA SENSITIVE RELAYS

SERIES 4
SPDT GENERAL PURPOSE. Modest cost. Suitable for aircraft applications, and vacuum-tube-operated relay circuits. Precision adjustments for pull on, drop out. Nominal contact rating 2 amp. Coil resistance up to 14,000 ohms.

SERIES 5
SPDT VERY SENSITIVE. Exacting performance as low as 5 milliwatts input. Undamaged by 500g shock. Nom. contact rating 2 amp. Coil resistance to 16,000 ohms.
Special Adaptations: — Built-in rectifier; two coil differential operation; constant voltage temperature compensation.

SERIES 41
SPDT AC — DC — KEYING. DC sensitivity compares with Series 4. AC sensitivity better than 0.1 V.A. Long life for *high speed keying and counting*. Mechanical life over 10^9 operations. Contact ratings to 5 amp. or over. Coil resistance to 14,000 ohms.

SERIES 6
MULTICIRCUIT POLARIZED. Single or double windings (differential). Resistance to 25,000 ohms. Contacts up to 4PDT, 5 amp. nominal rating.
Form X (Three Position or Null-Seeking) for automatic positioning, 2-way process control, etc. Form Y (biased — spring return). Used as conventional sensitive Relay, requiring complex contacts. Responds to D. C. of only one polarity. Form Z (latching — permanent, magnetic). Longer life, greater resistance to vibration than mechanical latch electrical reset relays.

SERIES 7
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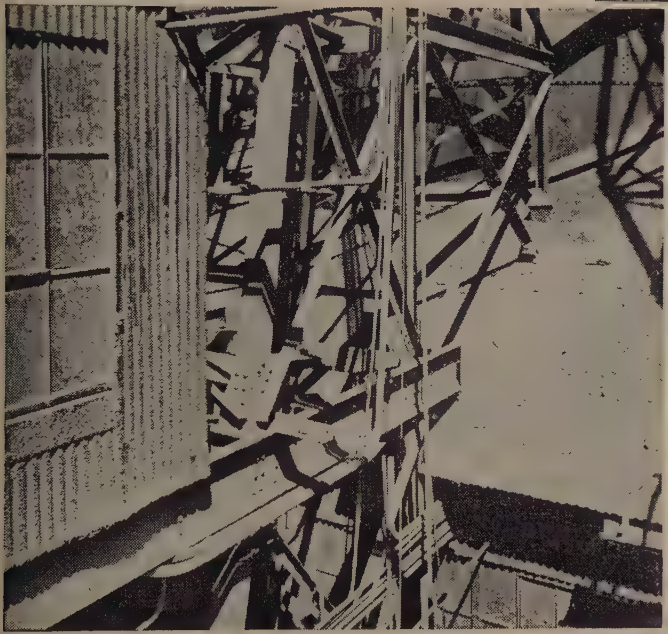

AT THE BARBERTON, OHIO, limestone kilns of the Columbia Chemical Division of the Pittsburgh Plate Glass Company, corrosion is an ever-present enemy of the power lines that feed the operating machinery.

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*Reg. U.S. Pat. Off. 48226

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PROTECTIVE ATMOSPHERES IN INDUSTRY . . Part IX

Brief descriptions of some of the typical instruments used in the controlling and measuring of various industrial gases, and the general principles upon which their operation is based

By A. G. HOTCHKISS and H. M. WEBBER
Industrial Heating Divisions, General Electric Company

GAS-ANALYSIS CONTROLLERS

Control of the analysis of gaseous mixtures is often a very important factor in obtaining uniform and reliable quality of work from a process. This factor becomes increasingly important when the analysis is at a critical point, variance from which might give results entirely different from those obtained under normal conditions.

GAS COMBUSTION CONTROLLER

A large portion of commercially used protective atmospheres is produced by partial or complete combustion of fuel gases or catalytic reaction of them, as already explained. An important phase of maintaining constant analysis of the product gases is the holding of a constant input-air to input-fuel-gas ratio, regardless of rate of flow. Variations in pressure might affect the results, but pressure regulators serve to eliminate this variable. If the fuel-gas analysis remains constant, automatic control of the input ratio will generally give sufficiently constant analysis of the output gas. Consequently, gas combustion controllers are commonly

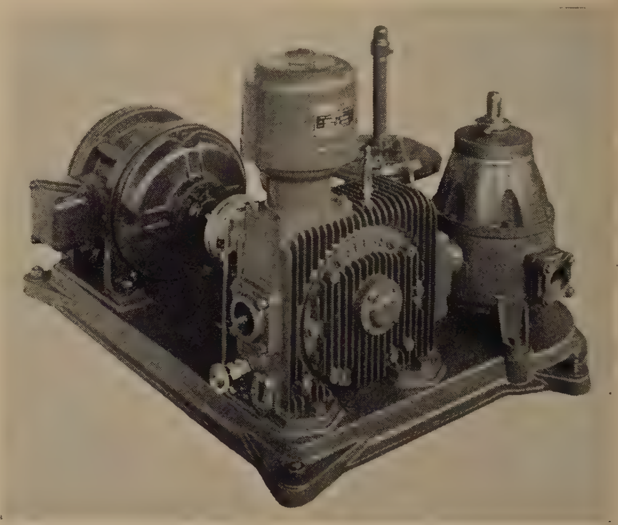

Fig. 90. Selas gas combustion controller used for holding constant ratio of input air to input fuel gas, for atmosphere gas converter, Neutralene gas producer, and for Thermalene gas producer

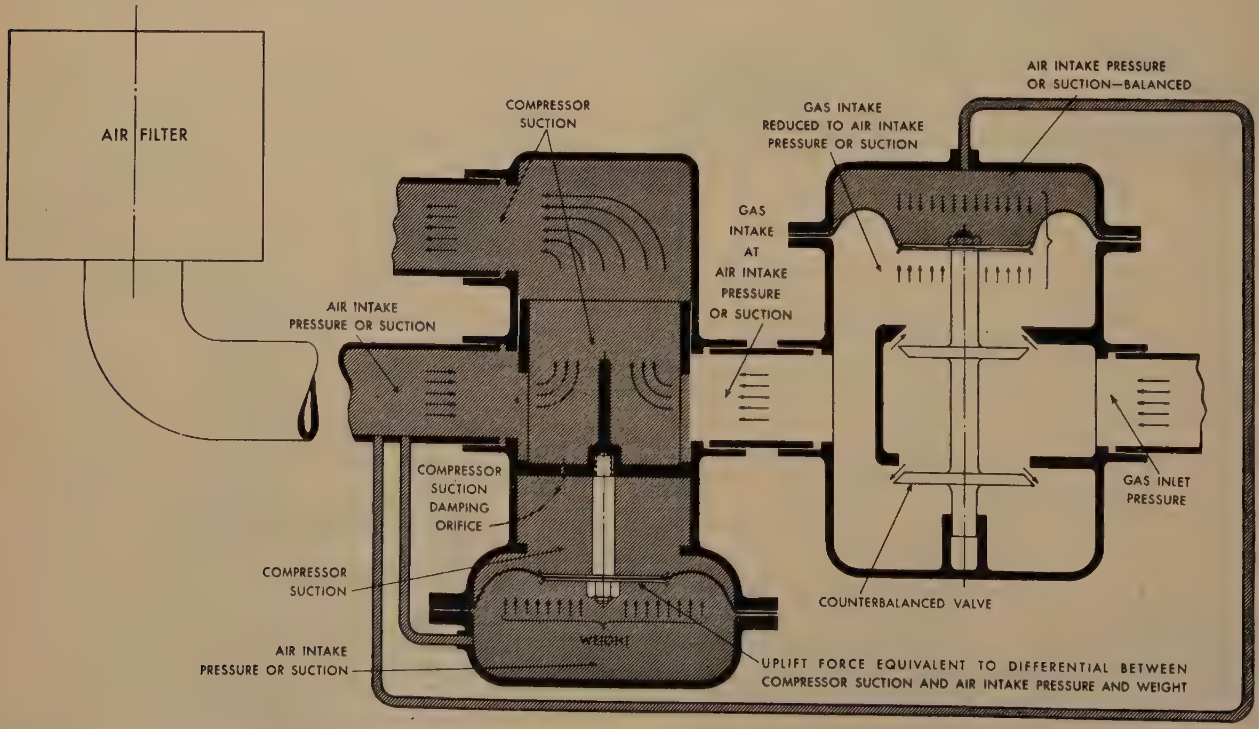
AIR FILTER
COMPRESSOR SUCTION
AIR INTAKE PRESSURE OR SUCTION
COMPRESSOR SUCTION DAMPING ORIFICE
COMPRESSOR SUCTION
AIR INTAKE PRESSURE OR SUCTION
WEIGHT
GAS INTAKE AT AIR INTAKE PRESSURE OR SUCTION
GAS INTAKE REDUCED TO AIR INTAKE PRESSURE OR SUCTION
AIR INTAKE PRESSURE OR SUCTION—BALANCED
GAS INLET PRESSURE
COUNTERBALANCED VALVE
UPLIFT FORCE EQUIVALENT TO DIFFERENTIAL BETWEEN COMPRESSOR SUCTION AND AIR INTAKE PRESSURE AND WEIGHT

Fig. 91. Diagram showing operating principle of gas governor and mixer for Selas gas combustion controller

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This article is so paged that, without mutilating other articles, it can be readily removed for filing as a group of full-size consecutive pages.—EDITOR

used on atmosphere-gas converters, Neutralene gas producers, and Thermalene gas producers.

Typical of these machines is the Selas gas combustion controller, FIGS. 90 and 91, made by the Selas Corporation of America, Philadelphia (Pa.). In addition to the driving motor, the machine is composed of three principal parts: (1) the mixer, (2) the gas governor, and (3) the compressor.

The Mixer

The mixer, shown at the left in the schematic diagram (FIG. 91) is an accurate sleeve valve consisting of a sleeve and a piston, each with two square orifices, one for gas and one for air. The piston can be rotated to adjust the air-gas ratio, and it moves vertically for changes in mixture volume. Normally the piston rotates only during manual adjustment. Vertical movement during operation takes place automatically to meet demand. The piston is carried by a vertical stem attached to a diaphragm beneath. As the mixture of air and gas is withdrawn from the mixer, the piston lowers or rises in proportion to the demand. The greater the demand, the higher the mixing-valve diaphragm lifts up, in response to the differential between the inlet air pressure and the suction of the compressor. This opens the orifices and assists in the accuracy of the volumetric air-gas ratio control.

The Gas Governor

The gas governor is an automatic disk valve which regulates the pressure at which gas is introduced to the mixer. It is shown at the right in the schematic diagram (FIG. 91). The pipe connection running from the air intake of the mixer at the left to the top of the gas governor at the right, above the diaphragm, transmits directly to the gas governor all variations in air pressure and assures that the pressure below the diaphragm equals that above. As a result, gas entering the mixer is always at the prevailing inlet air pressure, such equalization being necessary for constant mixing.

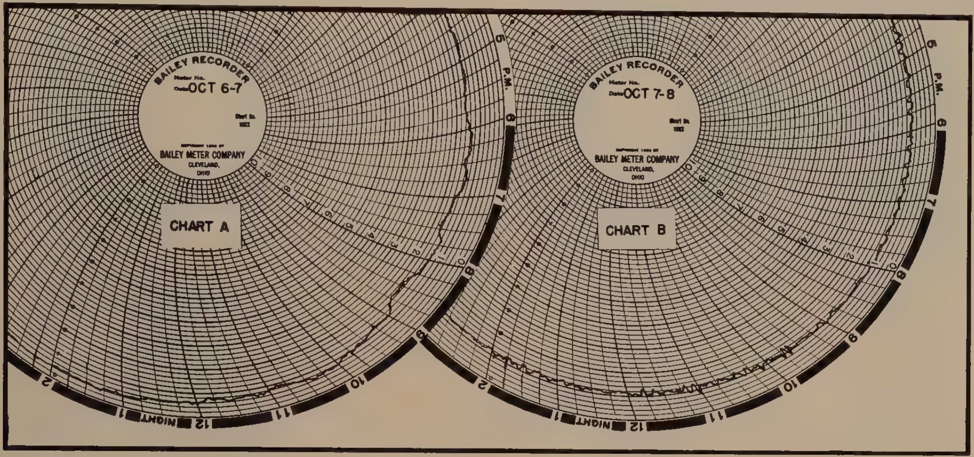

Fig. 92. Portions of charts from Bailey combustibles recorder and combustibles recorder controller

CHART A: Changes in output gas analysis from atmosphere gas converter, attributed to changes in analysis of the fuel-gas supply

CHART B: Effect of accessories illustrated in Fig. 93. Output gas analysis from atmosphere gas converter held constant by automatic adjustments of input air-gas ratio, controlled by the Bailey unit

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The following will facilitate the location of material published in earlier parts of this serial:

Part	*Issue*	*Figs.*	*Equations*	*Tables*	*Footnotes*
Part I	Nov. 1948, p. 29	1 to 6	None	I and II	None
Part II	Dec. 1948, p. 41	7 to 14	(1) to (18)	III and IV	(1) to (9)
Part III	Feb. 1949, p. 37	15 to 23	None	V and VI	None
Part IV	Mar. 1949, p. 25	24 to 35	None	VII	None
Part V	Apr. 1949, p. 25	36 to 41	None	VIII to X	(10) and (11)
Part VI	May 1949, p. 30	42 to 54	None	XI to XII	(12)
Part VII	June 1949, p. 33	55 to 70	None	XIII to XV	(13) to (17)
Part VIII	July 1949, p. 32	71 to 89	None	XVI	(18) to (23)

The Compressor and Pressure Governor

Suction for operating the mixing valve can be produced by any suitable compressor. The Selas machine shown makes use of a positive-displacement-type compressor equipped with built-in automatic pressure regulator, which maintains constant outlet pressure. Between the mixer and the compressor is a check valve which prevents back-pressure from the compressor when the machine is stopped.

COMBUSTIBLES CONTROLLER

The use of the gas combustion controller just described results in an analysis of the output gaseous mixture from an atmosphere-gas converter or other producers sufficiently constant for the majority of practical applications. When unusual accuracy and constancy in output-gas analysis is required, several factors have to be brought under control, for which the standard machine does not compensate automatically. These factors are: changes in the fuel gas—not necessarily changes in the Btu content of the fuel-gas, but in its chemical composition and specific gravity; changes in the moisture content of the air; contamination of the air as may, for instance, occur when the combustion controller is located in a room into which products of combustion from gas burners or from gas-fired ovens are discharged; and changes in the relative gas and air temperatures. Chart *A* in FIG. 92 shows fairly constant analysis in the output of an atmosphere-gas converter by this conventional means, between 4:30 and

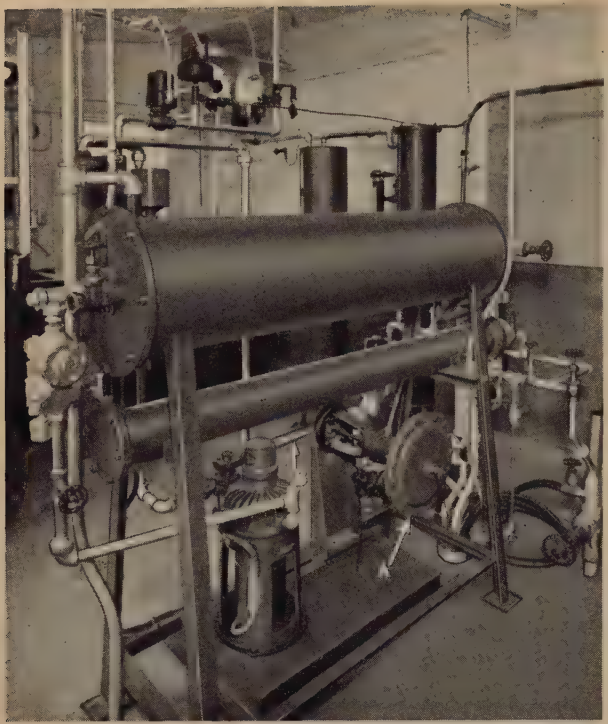

Fig. 93. General Electric atmosphere gas converter equipped with Selas gas combustion controller, a diaphragm-type air motor (A), and a lever (B), connecting the air motor to the rotating piston on the gas combustion controller

6:00 p.m. on a certain day. After 6:00 p.m., however, variations in analysis are noted, which are attributed to changes in analysis of the fuel-gas supply. The section of chart shown is from a Bailey combustibles recorder operating in conjunction with a General Electric atmosphere-gas converter burning coke-oven gas at approximately complete combustion. The initial setting shows about 1.6 percent combustibles (H_2 plus CO), but at 1:00 a.m., combustibles have decreased to about 0.4 percent.

The output-gas analysis can be maintained constant regardless of changes in fuel-gas or air analysis, by use of the Bailey combustibles recorder-controller, Fig. 88. This unit operates in conjunction with a diaphragm-type air motor *A* (Fig. 93) operating a lever *B* connected to the rotating piston on the Selas gas combustion controller. Any trend to a change in output-gas analysis is thus transmitted into proper rotation of the piston to change the input air-gas ratio as compensation, and thus retain constant combustibles in the output gas. Chart *B* shown in Fig. 92 indicates constant combustibles from 4:00 p.m. to 1:00 a.m., using the same fuel-gas as for Chart *A*, but in this instance the constancy is within ±0.2 percent.

The unit shown in Figs. 88 and 93 supplies inert gas for bubbling through kettles of resins while cooking. It is desired to avoid oxygen impurities in the gas because of an unfavorable effect oxygen would have on the quality of the work. By controlling the gas slightly on the reducing (or combustibles) side of complete combustion, as indicated, there is positive assurance that the work will always be of uniformly high quality. The machine supplies gas with 0.1 to 0.5 percent combustibles, using fuel-gas which varies from propane (2500 Btu) to butane (3200 Btu).

Gas Measuring Devices

Control of processes often requires a knowledge of the amount of flow of gases to various stations. For example, several furnaces supplied with gases for protective atmosphere from a single producer can best be operated satisfactorily by having a flow indicator in the gas line to each furnace so that the operators can be certain that the gas requirements are met. Atmosphere-gas converters and other producers require indication of input air and gas flow for determination of the air-gas ratio and the proper output rate for best performance of the machine. Three types of flow indicators are described below as being typical of such devices to facilitate applications of protective atmospheres.

TAPERED-TUBE FLOW GAGES

A common type of flow gage consists of a tapered tube with a metering float. Gas enters the bottom of the tube and leaves at the top. The float rises to a height depending on the rate of flow of gas through the tube; thus, by suitable calibration in the height for a gas of the specific gravity for which the tube is used, readings can be made directly in cubic feet per hour.

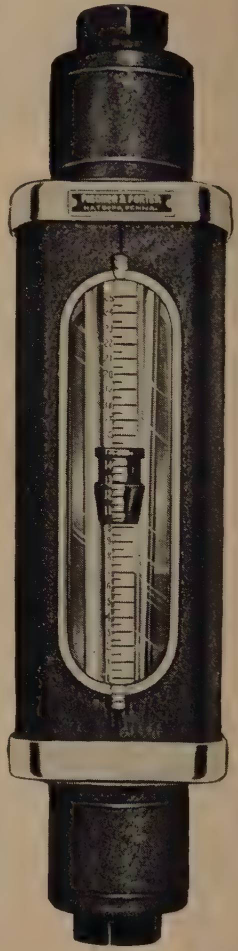

Fig. 94. Typical flow gauge used for protective atmospheres, with tapered tube and metering float. The unit shown is a Flowrator made by Fischer & Porter Company

FIG. 94 shows a Flowrator instrument made by Fischer & Porter Company, Hatboro (Pa.). It has a calibrated glass tube through which the float can be seen, and is suitable for measuring practically all of the gases normally encountered in protective atmosphere work.

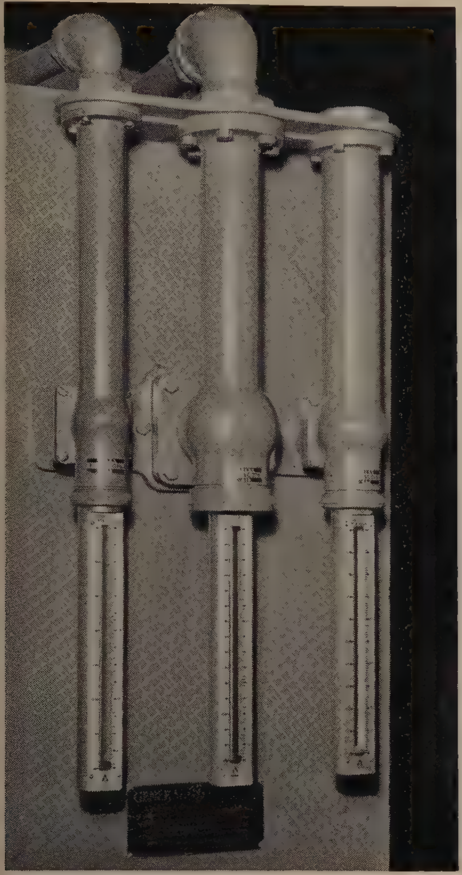

Fig. 95. Three Selas Floscopes having tapered metal tubes with metering floats and weights. Useful for measuring noncorrosive gases

Another similar unit is the Floscope, FIGS. 95 and 96, made by the Selas Corporation of America, Philadelphia (Pa.). This unit is particularly useful in the measuring of noncorrosive gases, such as dried sulphur-bearing gases, sulphur-free moist gases, air, etc. As indicated in FIG. 96, the unit has a tapered metal tube with metering float and weight. Below this measuring tube is an untapered glass tube with visual indicator disk, attached by a rod to the metering float. A calibrated scale is mounted alongside the glass tube on the metal guard.

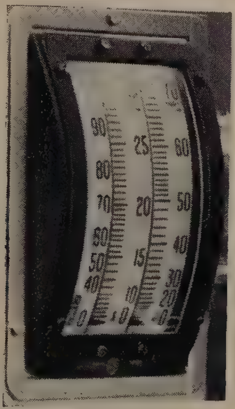

Fig. 97. Bailey diaphragm-operated flowmeter, which is particularly useful for measuring high rates of flow of gases

DIAPHRAGM-OPERATED FLOWMETER

Another type of flowmeter is the diaphragm-operated unit, which is particularly useful for measuring high rates of flow. The indicating unit is panel mounted, and operates in conjunction with orifices in the gas lines, measuring the flow by differential pressure on both sides of each orifice. Connections between the meter and the orifices are made by small-size piping. A typical flowmeter of this type is shown in FIG. 97, made by the Bailey Meter Company, Cleveland (Ohio.). It is provided with single or multiple edgewise-mounted scales with pointers which read directly in cubic feet per hour of gas or air for which the unit is calibrated.

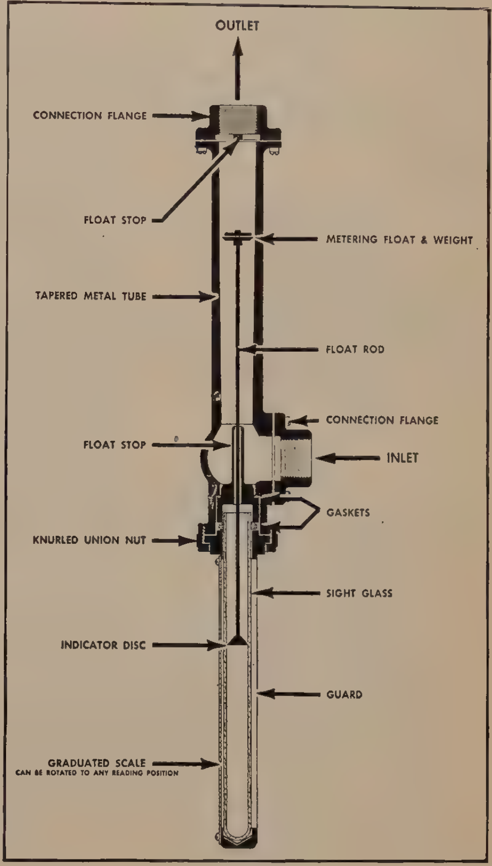

Fig. 96. Sectional diagram of Selas Floscope, showing the tapered metal tube at top and glass measuring tube at bottom, and related parts

(To be continued)

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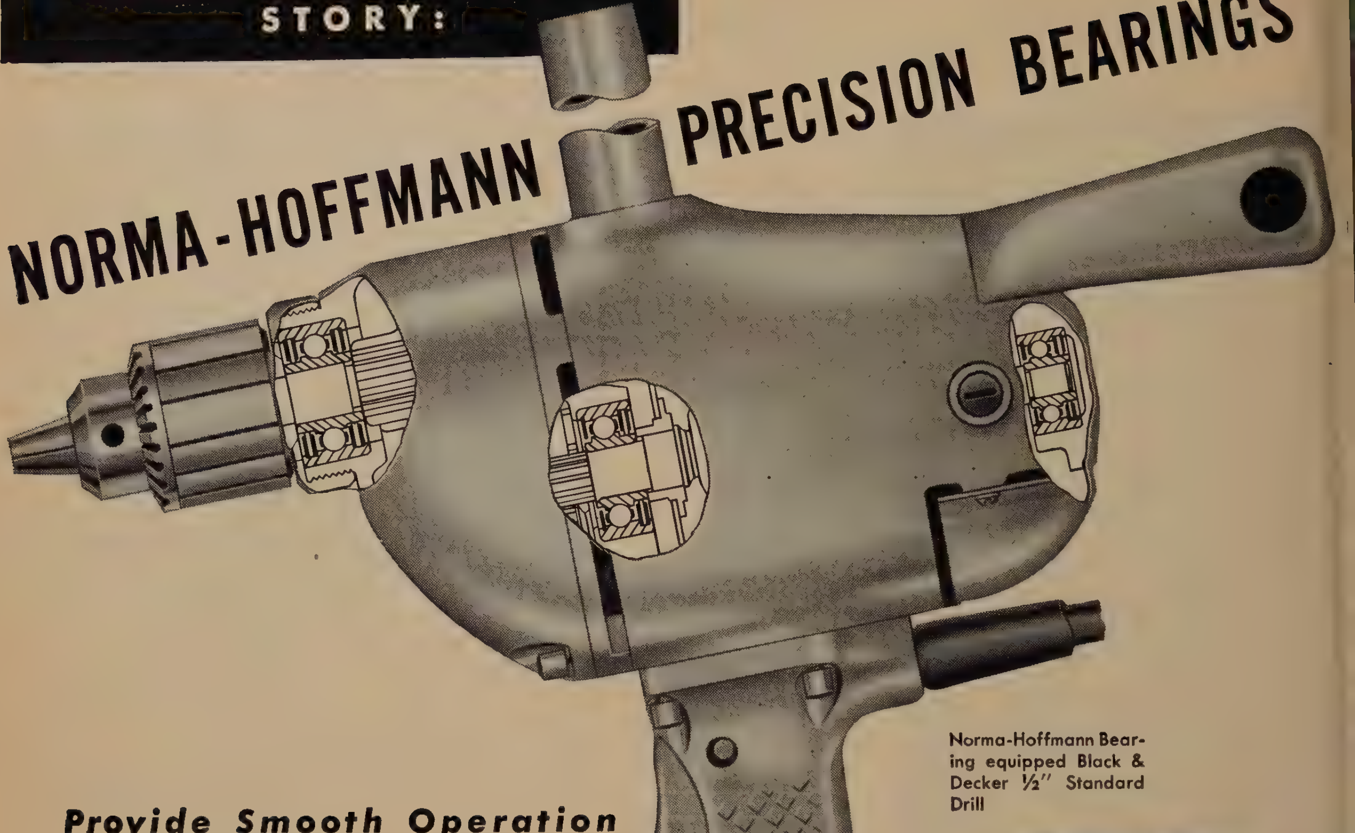

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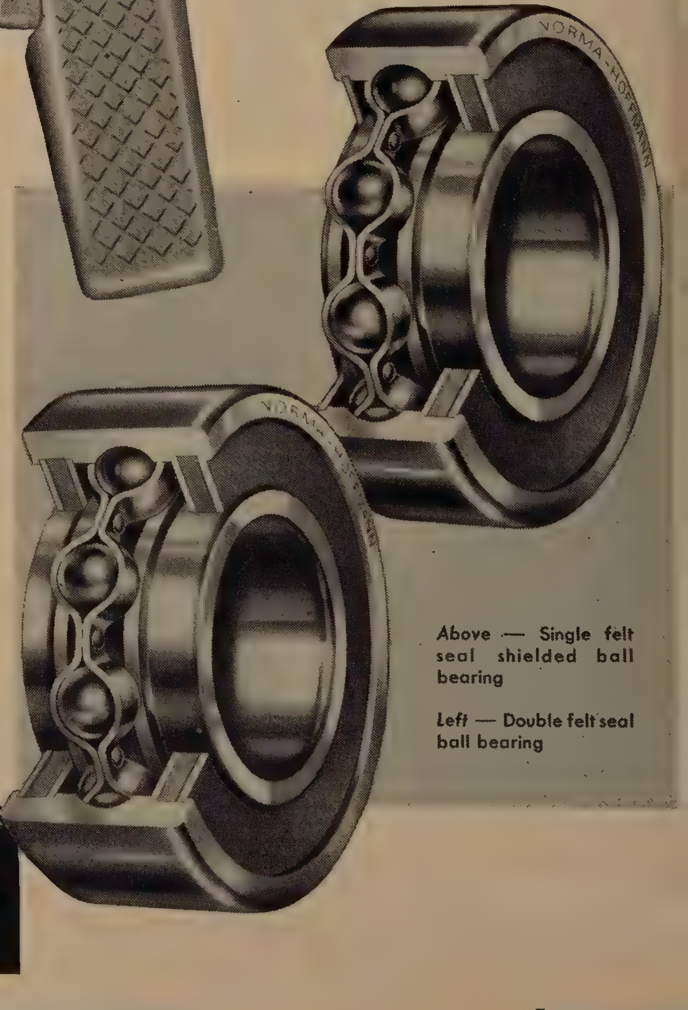

Above — Single felt seal shielded ball bearing

Left — Double felt seal ball bearing

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A NEW DISTORTION AND NOISE ANALYZER

This instrument with newly designed reactance-tube circuit for measuring total harmonic distortion and electrical noise will be useful also in meeting the FCC requirements for broadcasting-station checks of over-all distortion and noise

By DR. C. W. CLAPP
General Engineering and Consulting Laboratory
General Electric Company

C.W. Clapp

THE present trend toward more faithful reproduction of sound in all types of radio programs has emphasized the need for more precise instruments with which to analyze and test the performance of station equipment. These tests will take on new importance after August 1, 1949, as the new Federal Communications Commission requirements for proof-of-performance checks become effective. These regulations call for a measurement of the over-all distortion and noise of the complete broadcasting station at least once a year. Many stations already make such tests on a routine basis at frequent intervals. The distortion and noise analyzer described in this article was designed to make the required measurements when used in conjunction with an audio-frequency test oscillator⁽¹⁾ of low inherent distortion, and a station monitor⁽²⁾ for converting the r-f wave back into an audio-frequency voltage.

The distortion and noise analyzer may also be used for the measurement of total harmonic content of any complex wave within the range of the instrument or for the measurement of electrical noise.

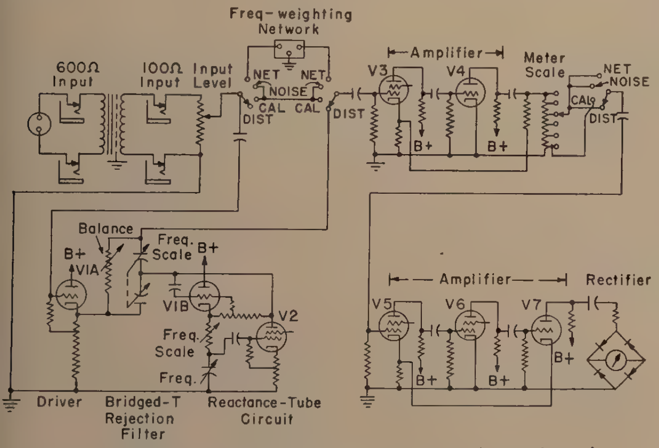

Fig. 1. Elementary diagram of a distortion and noise analyzer incorporating the reactance-tube circuit in a bridged-T rejection filter

Circuits designed to measure total harmonic distortion by filtering out the fundamental component of a wave have been described by several authors.⁽³, ⁴, ⁵⁾ A convenient form of distortion meter based on that principle utilizes either a bridged-T or a parallel-T null circuit⁽⁶⁾ to remove the fundamental, together with a suitable audio-frequency voltmeter to measure the remaining distortion components. In the circuit described by Hayes⁽⁵⁾, a reactance-tube circuit is substituted for the inductance element in a bridged-T filter to provide continuous frequency coverage conveniently.

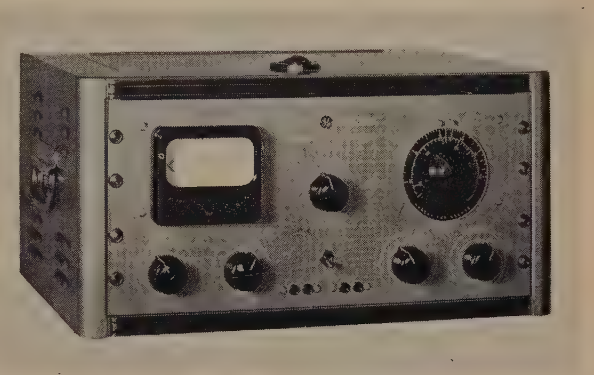

Fig. 2. The analyzer's case, with control panel, measures 11 in. high, 21 in. wide, and 15 in. deep; the analyzer weighs approximately 65 pounds

The analyzer described in this article has a reactance-tube circuit of novel design which permits Q values somewhat higher than those obtained by Hayes. As a consequence, it has been possible to make the analyzer continuously variable over the frequency range from 50 to 15,000 cycles per second, while the second and higher harmonics up to 30,000 cycles per second are attenuated less than 0.5 decibel.

DESCRIPTION OF INSTRUMENT

FIG. 1 is an elementary diagram of a distortion and noise analyzer incorporating the reactance-tube circuit in a bridged-T rejection filter. A front view of the analyzer is shown in FIG. 2.

If the signal to be analyzed is on a balanced line, it is applied through jacks and the line-bridging transformer to the potentiometer input level control. If the input signal is carried by a line having one side grounded, it is applied directly through other jacks to the input level control. The input signal is then fed to a tube (*V1A*) which operates as an impedance changer to drive the bridged-T rejection filter. The capacitive arms of this filter are composed of several capacitors,

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This article is so paged that, without mutilating other articles, it can be readily removed for filing as a group of full-size consecutive pages.—EDITOR

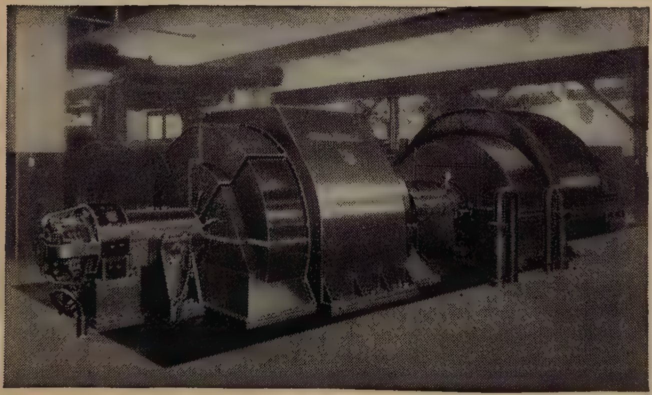
(1) Numbered references are listed at the end of the article.

different values of capacitance being selected by a switch to cover the required frequency range.

The reactance-tube inductive arm of the filter uses a triode (*V1B*) in the driver stage and a pentode (*V2*) for the reactance tube. The resistive component of the phase-shifting network in the cathode circuit of triode *V1B* is supplied by a group of resistors. The value of the resistance is varied in steps, by a switch, to provide five frequency ranges. A variable capacitor in series with this resistor is used to vary the equivalent inductance, and hence the null frequency, continuously over any one of the five ranges.

The Q of the equivalent inductance, and hence the sharpness of the null, is much improved by the addition of driver tube *V1B*. This tube is used to drive the phase-shifting network and the plate load resistor for tube *V2*, both of which would otherwise contribute appreciable losses to the circuit, reducing the sharpness of the null. A resistor, bridged across the capacitive arms of the rejection circuit, is adjusted as required to obtain an accurate null balance.

The output of the rejection circuit is amplified by two linear amplifiers in tandem and separated by a calibrated attenuator. Each of the amplifiers is stabilized by approximately 25 decibels of negative feedback. The output of the second amplifier is rectified by a full-wave crystal diode bridge and read on a microammeter calibrated to read percent distortion.


9,000 hp Synchronous Motor, manufactured at C-G-E Peterborough Works, driving a centrifugal compressor at a large Canadian nickel mine.

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Rectified and filtered direct current is supplied to the heaters of the first three tubes in the circuit to keep hum at a satisfactorily low level.

The response of the rejection circuit of this distortion analyzer is shown in Fig. 3. The response is shown for three different null frequencies taken on the 500-1500-cps range. When tuned to 500 cps, the shape of the response curve corresponds to the case of an inductance with shunt losses and a Q of about 4. With null frequency at 1500 cps, the response corresponds to an inductance with series losses and Q of about 5. When tuned to 1000 cps, the shape of the response curve is intermediate between that found at the high end and that found at the low end of the band.

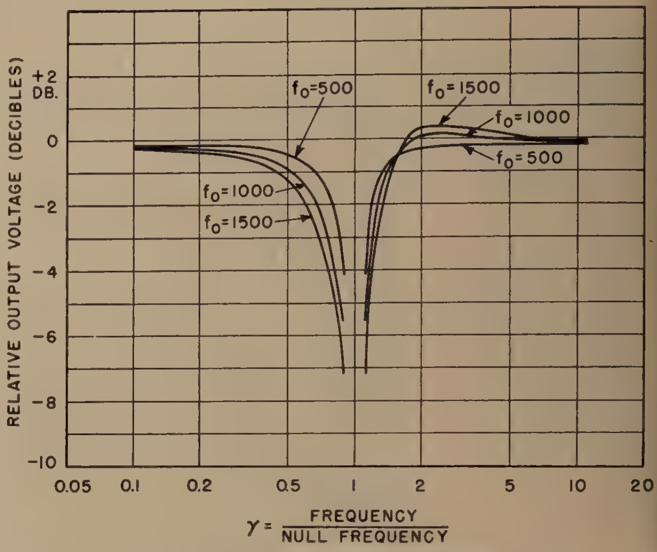

Fig. 3. Frequency response of the rejection circuit

The distortion range covered is from one percent to 100 percent full scale; the frequency range is 50 to 15,000 cps fundamental. The accuracy of the distortion measurements is approximately ±5 percent of full scale, ±0.1 percent of distortion.

By means of a selector switch, measurements of line noise can be made with the same equipment, either through a flat amplifier or through a frequency-weighting network that can be connected to terminals inside the case. With the flat amplifier, the response is uniform within 0.5 db from 20 to 30,000 cps, using the balanced input connection, or from 20 to 70,000 cps, using the unbalanced input connection.

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(2) "F-M Station Monitor," by H. S. Summerhayes, Jr., *Communications*, April 1946, vol. 26, pp. 68-74.

(3) "Note on Fundamental Suppression," by H. M. Wagner, *Proc. of IRE*, vol. 23, Jan. 1935, pp. 85-88.

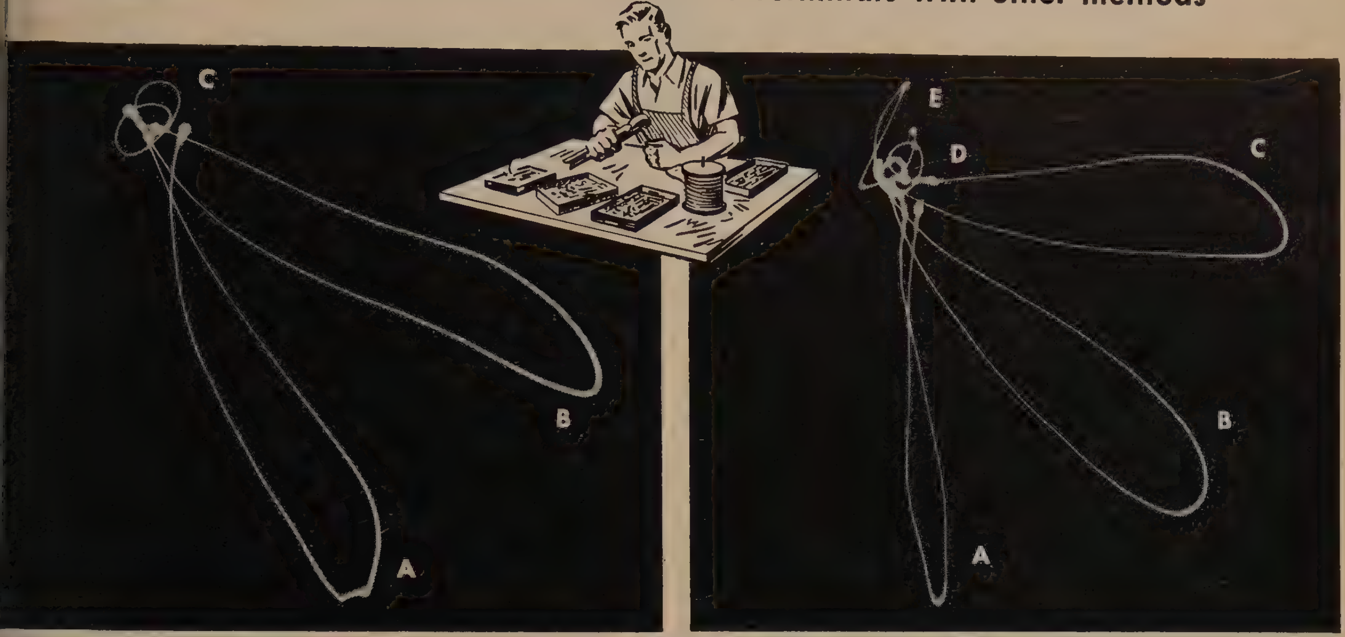
(4) "Fundamental Suppression Type Analyzer," by J. H. Piddington, *Proc. of IRE*, vol. 24, April 1936, pp. 591-596.

(5) "A New Type of Practical Distortion Meter," by J. E. Hayes, *Proc. of IRE*, vol. 31, March 1943, pp. 112-117.

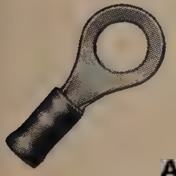
(6) "Bridged-T and Parallel-T Null Circuits for Measurements at Radio Frequencies," by W. N. Tuttle, *Proc. of IRE*, vol. 28, Jan. 1940, pp. 23-29.

HERE'S TIME SAVED!

Time Study compares the easy steps in applying
AMP Pre-Insulated Solderless Terminals with other methods

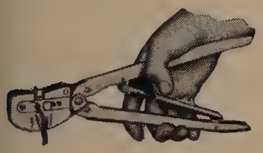


Time-motion photographs, taken from above, trace operator's hand movements as he applies Terminal to Wire.



A

Worker holds stripped wire in one hand and reaches for AMP PRE-INSULATED Solderless Terminal* with other hand. Then slips terminal over wire.

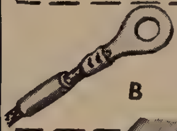


B & C

Worker picks up AMP hand tool and crimps terminal to wire. One crimping operation gives electrical connection, mechanical strength, and insulation support!

A

Worker holds stripped wire in one hand, reaches for insulation sleeving, and slips it over wire.



B

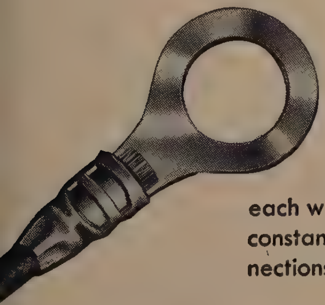
Worker reaches for non-insulated terminal and slips it over wire.

C & D

Worker picks up hand tool and crimps terminal.

E

Worker then must slide insulation sleeving carefully back over the connection.



*AMP PRE-INSULATED terminals have special plastic insulation bonded to the terminal—it cannot slip or be removed. There is no extra sleeving to be stocked or handled. Available in a wide variety of tongue shapes to suit every wiring requirement, these terminals are color-coded for each wire size range from # 22-10. AMP PRE-INSULATED TERMINALS constantly make savings by lowering the installed costs of insulated connections, and increasing their electrical and mechanical performance.

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AIR DISINFECTION BY GERMICIDAL ULTRAVIOLET ENERG

Air-borne respiratory micro-organisms a source of infection. Tests in room under controlled conditions demonstrated the effectiveness with which thes organisms can be destroyed at low cost by suitably mounted germicidal lam

Matthew Luckiesh

A. Hadley Taylor

Thomas Knowles

By
MATTHEW LUCKIESH
A. H. TAYLOR
THOMAS KNOWLES
Lighting Research Laboratory
Lamp Department
General Electric Company
Nela Park, Cleveland

TWO of the principal avenues by which communicable diseases spread are: (a) direct contact with a person who is infected with the disease or is acting as a carrier, or contact with some article such as dishes, cutlery, etc., contaminated with bacterial or viral organisms of the disease; (b) breathing air-borne micro-organisms which may have been expelled into the air by an infected person.

The relative importance of these two modes of infection will vary from place to place because of many controllable and uncontrollable factors. Methods of combating infection by contact are well developed but air disinfection has not received the attention it deserves.

Careful researches have shown that some of the respiratory organisms expelled into the air during sneezing may remain air-borne and viable for one or more hours.(1) Even the practice of sneezing or coughing into a handkerchief does not prevent the organisms from becoming air-borne when the handkerchief is used again later.(2) The authors have found that such organisms may live 36 hours or longer when collected on sterile plates without nutrient, hence they may be potentially infectious for many hours after leaving their host.(3)(4)

AIR-DISINFECTION METHODS

The oldest and commonest method of reducing the bacterial content of air in occupied rooms is by ventilation, which replaces contaminated room air by filtered or outdoor air. While this might reasonably be expected to reduce the concentration of air-borne organisms by dilution, Yaglou and Wilson(5) found that a high-velocity air stream which stirred up the floor dust actually increased the bacterial content of the air with increasing numbers of air changes per hour. Furthe more, there is a practical limit to the frequency of a changes because of the creation of drafts which add t the discomfort of the room occupants. In the cool climates, the economic aspect of increased air chang cannot be ignored.

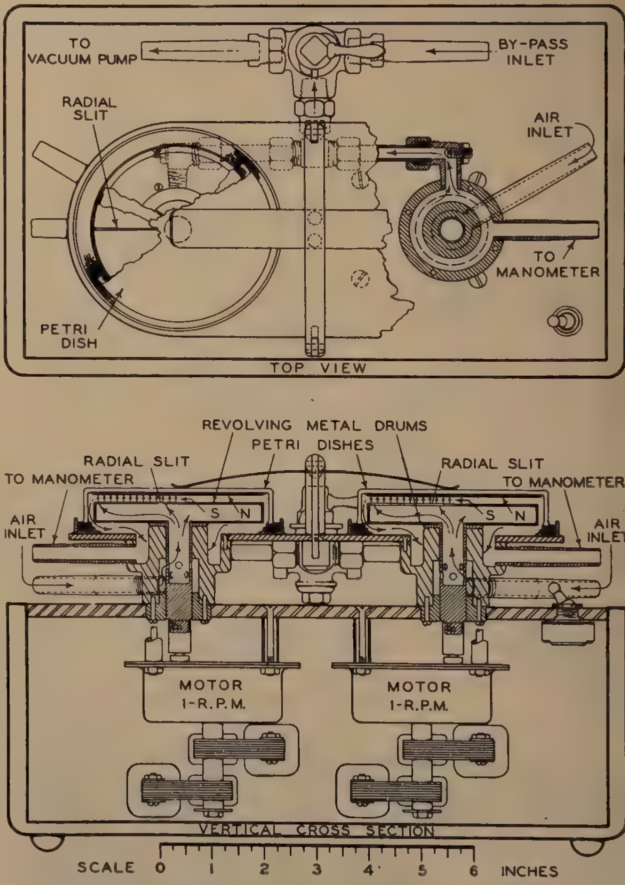

Fig. 1. Plan and elevation views of a duplex radial-jet air-sampler oper- ating on the same principles as the Bourdillon slit sampler

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(1)Numbered references are listed at the end of the article.

This article is so paged that, without mutilating other articles, it can be readily removed for filing as a group of full-size consecutive pages.—Editor

Another method of air disinfection is the use of aerosols which are added to the room air by suitable vaporizing apparatus.

The third method, which is the principal subject of this article and of our researches for many years,(3) is the use of short-wave ultraviolet energy radiated by so-called germicidal lamps. These lamps are very efficient sources of λ2537 energy, which is in the spectral region of maximum germicidal effectiveness. Since this ultraviolet energy can produce conjunctivitis and erythema if the eyes and skin are exposed to it for a sufficient period, special fixtures and installations have been developed for these lamps. The fixtures, employing reflectors of suitable material, are usually mounted on the walls to project the germicidal energy across the room above eye-level. Most oil paints reflect less than 10 percent of this energy, hence relatively little is reflected by ceiling and walls into the lower occupied part of the room. It has been found that this method is safe and effective.

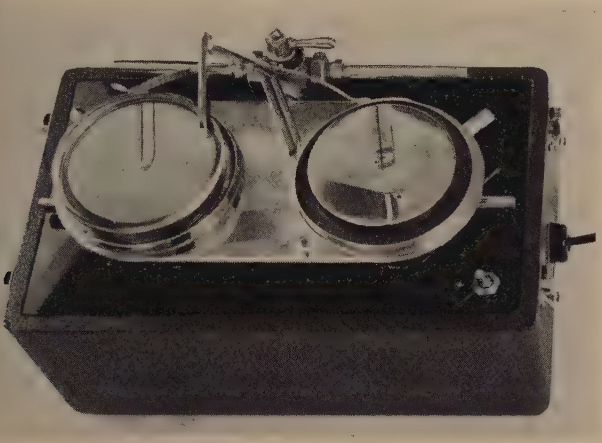

Fig. 2. Photograph of the duplex radial-jet air-sampler shown in Fig. 1 and used in the tests

SAMPLING AIR TO DETERMINE BACTERIAL CONTENT

The authors have developed air-samplers suitable for use in the field to measure the bacterial content of the air.(6) They are very useful in measuring air contamination by heterogeneous micro-organisms. However, direct appraisal of air contamination solely by organisms of respiratory origin is very difficult at present, some of the reasons being these:

(a). Many of the micro-organisms collected have origins other than the respiratory tract.

(b). There is no known culture medium which will grow the organisms of respiratory origin and inhibit all others.

(c). No single organism has been found which can be used as a satisfactory index of air contamination by respiratory organisms. Various workers have used different organisms such as alpha-hemoloytic streptococci, lactobacilli, diptheroids, etc., but there is no general agreement on a standard organism.

(d). The presence of viruses cannot be determined by the ordinary sampling and culturing techniques.

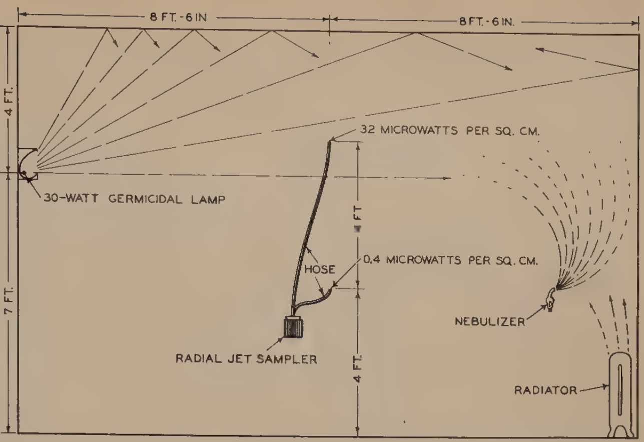

Fig. 3. Elevation diagram of arrangement of apparatus to measure rate of destruction of air-borne respiratory micro-organisms, from nebulized saliva, by germicidal ultraviolet radiation

DETERMINING EFFECTIVENESS OF GERMICIDAL-LAMP INSTALLATIONS ON AIR-BORNE RESPIRATORY MICRO-ORGANISMS

In view of the foregoing facts, it is obviously difficult to directly appraise the degree of disinfection of air achieved in an occupied enclosure by germicidal energy. Consequently, the authors have approached the problem more directly by contaminating the air of a closed room with fresh saliva atomized into the air as a mist of very fine droplets. The size of droplets collected at different parts of the room was found to be approximately 1μ.

The air-sampler used in our tests was a modified Bourdillon slit-sampler which has already been described.(7) A later design of this sampler(8) is illustrated in FIGS. 1 and 2. A vacuum pump draws air simultaneously through the two identical units of the sampler. It issues at high velocity through radial slits in two drums (rotating at one revolution per minute) onto the culture media in inverted petri dishes. These dishes are held securely against rubber gaskets by means of a flat spring. This type of sampler avoids contamination of the outside of the petri dishes by organisms being drawn through the sampler, thus making it possible to use the sampler in tests with pathogenic organisms. Furthermore, the upper part of the sampler, which may become contaminated, can be removed and autoclaved.

When respiratory micro-organisms become air-borne, directly from the occupants of a room or by atomization of saliva into the air, they gradually settle out, die, or are carried away in air escaping from the room. To obtain data on the normal rate of disappearance of these organisms from the air, when carried on very fine droplet nuclei, fresh saliva was nebulized with a No. 40 DeVilbiss nebulizer into the air of a closed room 17 ft square and 11 ft high. Nebulization was stopped at the end of an hour and the air was sampled at various times over a period of two hours, using the duplex radial-jet sampler with hoses to draw air from heights of 4 and 8 ft above the floor in the center of the room. A 30-watt germicidal lamp in a parabolic reflector was mounted 7 ft above the floor on one side of the room to irradiate the upper air. The arrangement of the room and apparatus was as shown in FIG. 3.

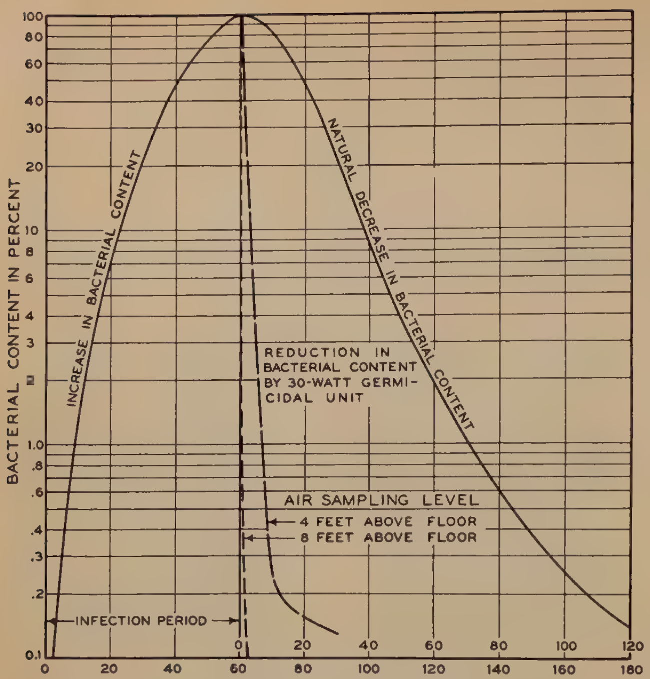

Fig. 4. Some results of tests as measured with the duplex radial-jet air sampler. Saliva was atomized into the air of a closed room (Fig. 3) for an hour, the air being sampled frequently. At that time the atomizer was stopped and a single 30-watt germicidal lamp unit irradiating the air above the 7-ft level was turned on. Air samplings at two levels in the center of the room with and without the germicidal unit, show its effectiveness in destroying these organisms

FIG. 4 illustrates the rate of build-up of the respiratory organisms in the air during the nebulization period of one hour (lamp not burning) and the rate of decrease without and with the germicidal lamp operating. FIG. 5 is a magnified plot of data obtained under similar conditions in the same room on another day. Many such tests have been run in this room, the charts presented here being typical.

To determine whether comparable results would be obtained in a school classroom having an installation of four 30-watt germicidal lamp fixtures, the same technique was used. Nebulization of saliva continued *throughout the whole test period.* The work was done during a vacation when no pupils were present. The results obtained are shown in FIG. 6, another striking illustration of the effectiveness of the lamps in disinfecting air. The lamps and reflectors were not cleaned before the test. Cleaning them afterwards increased their output 50 percent.

While the organisms in the saliva were not typed, it would appear logical to assume that pathogenic organisms found in the mouth and throat of persons having respiratory diseases would be of comparable resistivity. Consequently, comparable results should be achieved with pathogenic respiratory organisms.

All these tests demonstrate the rapidity with which contaminated air in occupied interiors can be disinfected with germicidal energy, even at the occupancy level where there is no direct radiation from the lamps and the intensity of energy reflected from walls and ceiling is approximately ½ microwatt per sq cm. Other tests in our laboratory indicate that the rapid reducti at the lower levels in the room is due partly to dire destruction of some of the organisms at low intensiti of energy at those positions and partly to dilution b convection currents of air which has been partially di infected in the region of direct irradiation. Tests of a circulation in the 17-ft square room on one day show that the air was moving upwards throughout the roo at 10 to 30 ft per min except in the corners, where th air flow was downward. No fans or other means we used to accelerate the interchange of air in the upp and lower parts of the room. In an occupied room th circulation rate would be promoted by the hot radiato or incoming warm air from the heating plant, th warmth of human bodies, the air breathed out, et

These tests definitely show that the reduction of ai borne respiratory micro-organisms is not limited to th

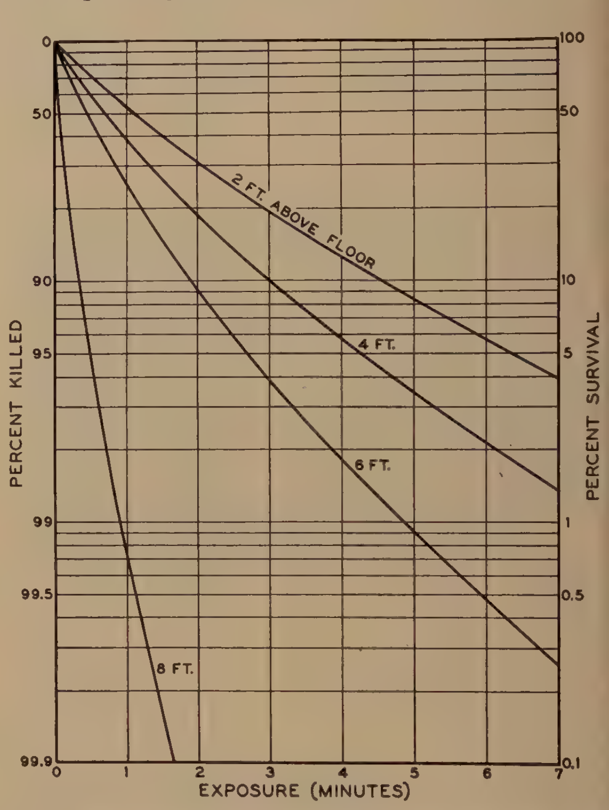

Fig. 5. Results of another test made under the same conditions as those for Fig. 4

area of high-intensity irradiation—the air above ey level. Other tests have shown that if these organism settle onto the floor, over 90 percent of them are d stroyed in one hour by the low intensities of germicid energy reflected from the ceiling. This fact was estab lished with an installation which did not produce un safe intensities at occupancy levels in the room.

The Committee on Sanitary Engineering, Nation Research Council, Division of Medical Sciences, in recent report(9) makes the following statement: "Th two primary considerations for the successful applica tion of ultraviolet light to the disinfection of air ar (a) supplementing irradiation with dust suppressio measures, since ultraviolet light is not efficient again bacteria and virus protected by dust; and (b) attainin radiation of sufficient intensity but not so high as to ffect the eyes or skin of occupants." Part (a) infers hat the dust is highly absorptive for germicidal energy. However, the authors have found that when very dusty germicidal lamps and fixtures are cleaned, the light and he germicidal energy increase by approximately the ame percentage. This shows that the dust is substantially nonselective in its absorption. Since amounts of dust which are tolerable in the air do not appreciably educe the light, the same would be true for the germicidal energy.

Another aspect of the dusty atmosphere is the fact hat the dust may carry many harmless saprophytic organisms which are much harder to kill. Fig. 7 shows ethal-effectiveness curves for various types of airborne organisms, including respiratory organisms and organisms found in the dust in an office and in the air of theaters during the time of cleaning. The techniques used to obtain these data have already been described. It will be seen that saprophytic organisms found on the dust particles are much more resistant than those in saliva, requiring approximately 500 times greater exposure to produce the same degree of killing. However, the authors believe this to be largely a difference in innate resistance of the types of organisms normally inhabiting the dust rather than to any major protective effect of the dust.

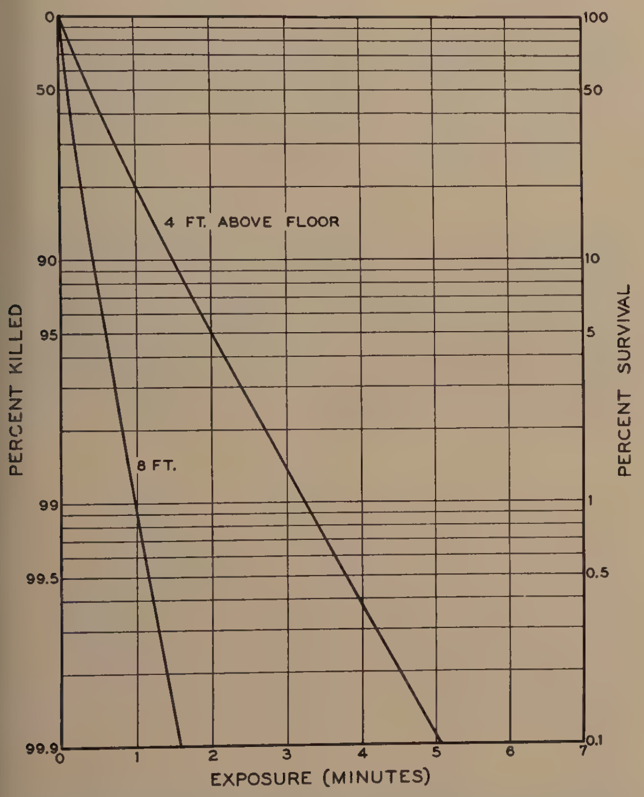

Fig. 6. **Results of a standard germicidal installation in killing respiratory organisms in a classroom. Four 30-watt germicidal units were so installed on the walls as to irradiate the air above the 7-ft level. The concentration of organisms decreases rapidly at the 8-ft level. Saliva was nebulized continuously into the vacant schoolroom throughout the period of the test**

CLINICAL TESTS

Such laboratory tests as those that have been described show the effectiveness of germicidal energy in destroying air-borne micro-organisms which can contribute to the spread of infections. However, as already mentioned, there are other channels through which the infections may spread and it is not easy to appraise the direct result of air disinfection in the control of such infections. The most reliable clinical data which have been published to date result from statistical studies involving large numbers of individuals. They show reductions of 15 to 50 percent in the incidence of infectious diseases. Several of these studies are listed in reference(10) at the end of this article.

ECONOMICS OF AIR DISINFECTION

A single 30-watt germicidal lamp in a suitable fixture consumes approximately 40 watts in lamp and auxiliary. Extensive data indicate that, for occupied rooms, one of these units is sufficient for a floor area of approximately 200 to 300 sq ft if properly designed and installed. The cost of operating such a fixture eight hours daily, including lamp renewal and reasonable amortization of the original cost, is of the order of one dollar a month at the present time.

From the viewpoint of monetary cost alone, saving the loss of one day's time in one year by one worker would pay the cost of operation. In many public schools the amount of financial aid from the state is based on the pupil-days of attendance. Thus the loss of time due to preventable illness reacts financially on the school and even a small gain in attendance is of importance.

In a military camp any measure which reduces the recruits' loss of time because of illness is of obvious value in reducing the cost of their training. In time of war, the reduction of time required to provide adequate training for military service may be of vital importance. Obviously, the cost of man-hours lost by reason of preventable illness far outweighs the cost of operating the germicidal lamps, even if the improvement is only half that found in studies in various military camps.

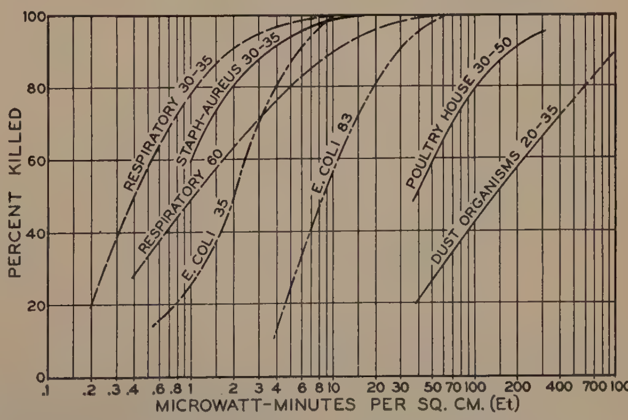

Fig. 7. **The resistivities of various air-borne organisms are shown by the dosages *Et* required to kill or inactivate any given percentage of the organisms. The numbers on curves indicate percent relative humidity. The dust organisms were from air stirred up in an office and two movie theaters during cleaning**

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AIR DISINFECTION

(Continued from preceding pag

In addition to monetary costs, humanitarian considerations should also be given great weight as the are in various other trends in improving hygienic conditions for the prevention of the spread of infectiou diseases. Some authorities have taken the stand tha reductions in respiratory illnesses of the order of 2 percent, such as have been shown in well-ordered investigations, are not sufficient to warrant the use o germicidal lamps. Such a stand is scarcely justifiable Experimental data, obtained from such investigation as we have conducted in our laboratory, prove tha respiratory micro-organisms are quickly destroyed b germicidal energy and the clinical proofs of effectiveness in the control of infections in numerous place establish the usefulness of the lamps on a firm foundation. No large reduction in air-borne infections i necessary to justify the proper use of germicidal lamp either on an economic basis or for humanitarian reasons From the mass of evidence yielded by controlled laboratory researches and clinical tests, germicidal radian energy is now entitled to open-minded consideration b those interested in hygiene and public health.

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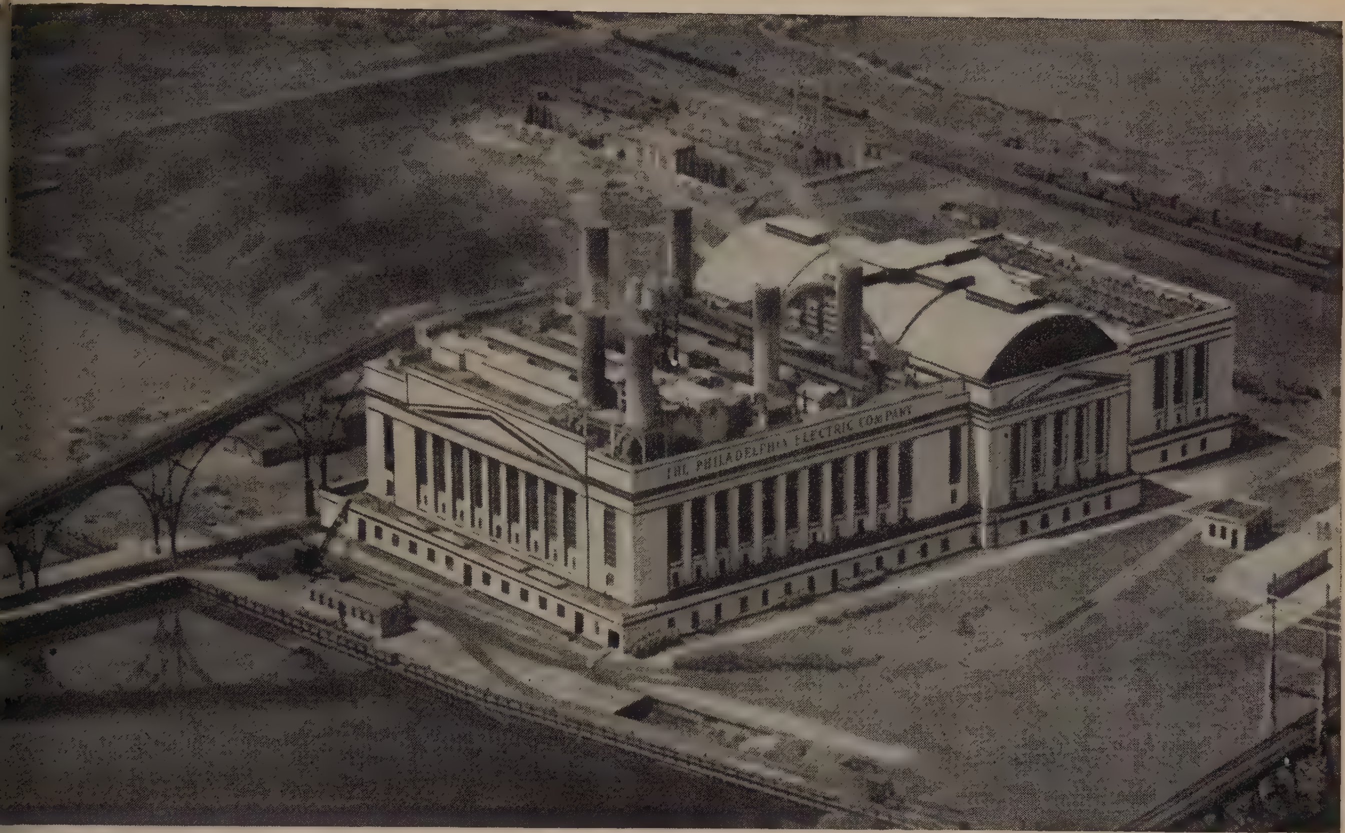
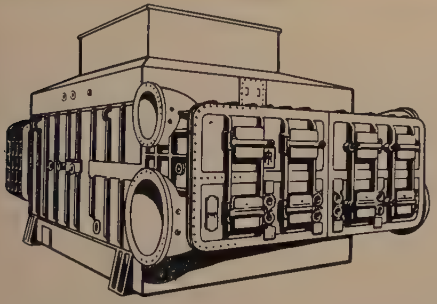
PHILADELPHIA ELECTRIC CO. TO INSTALL 75,000 SQ FT CONDENSER





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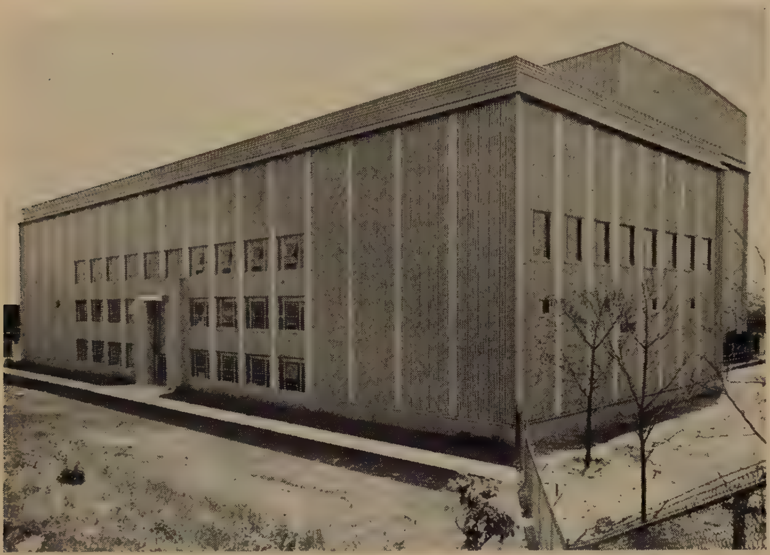
HIGH LIGHTS AND SIDE LIGHTS

New High-voltage Engineering Laboratory

To provide unsurpassed facilities for the production and study of high-voltage phenomena, a two-million-dollar laboratory was recently built at the Pittsfield Works of the General Electric Company. It supplants earlier facilities with which much notable research has been done, and it will make possible the extension of that and kindred lines of research relating to lightning, to protection against lightning, and to the development and operation of ever-better high-voltage apparatus and equipment of commercial types.

When designing the laboratory, special attention was given to making its facilities flexible and to combining operating convenience with safety, and utility with good appearance. Architecturally, it consists of a high-bay building that contains the High-voltage Hall, and a low-bay building that houses several smaller test areas (including an air-conditioned room), the power-supply apparatus, the offices and other rooms needed in the conduct of the laboratory work. At the rear of the High-voltage Hall is an outdoor test area into which one of the high-voltage generators can be moved either for testing apparatus that is too large to bring into the building or for applying tests to a typical section of transmission line.

Included in the test equipment are: two 5100-kv (7500 kv maximum peak) impulse generators (one being the mobile unit mentioned in the previous paragraph), four lower-voltage impulse generators, a 260,000-amp (peak) surge generator, and transformers of various ratings, together with the necessary control berths, pits, oscillographs, and other instruments and devices.



The new High-voltage Engineering Laboratory. Partially visible behind the low-bay building is the adjoining high-bay building that contains the High-voltage Hall

Magnetic Comparator Speeds Testing

Use of a magnetic comparator in production-line testing of stock steel and small ferrous parts has enabled the Winchester Repeating Arms Company of New Haven (Conn.) to step up its checking rate to approximately 1000 units per hour.

Prior to installation of the comparator, classifying was accomplished by various spot checks and tests which required fro a half day to several days to complet Now all units of small arms and ammun tion, as well as flashlights, dry-cell batte ies, and various brass specialty items, ca be quickly checked, right on the line, l a nondestructive test. The company al uses the instrument in its laboratory check samples and small production run

Magnetic comparator checking steel tube samples in the test laboratory

In operation, the apparatus compar rods, bolts, springs, and small fabricate parts with a preselected standard of th same size and shape to detect a differen in composition, heat treatment, or othe characteristics which alter the resistivi or magnetic properties. In many cas the comparator will distinguish betwee steels whose hardness differs by as litt as two points of Rockwell.

A portable steel case containing the in dicating instrument is connected to tw identical coils of wire. In the center of on coil is placed the sample standard known composition; the parts to be teste are placed in the other. On large piec such as forgings, a pair of gage head which rest on the surface of the par being compared, can be used instead the coils. The power supply required 100 watts, 115 volts, 60 cycles.

Altitudes Measured with Boiling Liquid

A scientific cousin to the teakettle h been developed to measure altitudes high that ice is formed in boiling wate The instrument, a new type of hypson eter, is carried aloft by weather balloo and measures altitudes up to 30 miles.

Operation of the hypsometer is base upon the principle that the boiling poi of a liquid drops as the altitude increase As the weather balloon ascends, th steadily lowering boiling point is record by the hypsometer and radioed to th ground. The information enables obser ers to determine the balloon's altitude.

Designed to replace bellows-type d vices, which expand and contract wi changes in air pressure but are n accurate at extremely high altitudes, th new instrument looks like a radio tube b can best be described in terms of miniature teakettle.

The "kettle" part is a small vacuu flask which holds about five thimblefuls liquid. Water is sometimes used, but liquid with a lower freezing point, su as carbon disulphide, usually is chose Inserted in the open end of the "teakettl is a thermistor, a temperature-sensiti

By measuring the decreasing temperature of boiling liquid in its glass vacuum bottle while rising in a weather balloon, then radioing the data back to earth, this tiny instrument assists in studies of weather at altitudes far above records established by man

resistor, the electrical resistance of which changes as the temperature changes. The temperature-sensitive end of the thermistor is surrounded by steam given off by the boiling liquid in the "kettle" end of the hypsometer.

The steam temperature changes as the altitude increases, and so does the electrical resistance of the thermistor. The changing resistance is transmitted to the ground by the balloon's radio. From this information observers can calculate the boiling point and, consequently, the altitude of the sphere in the sky.

Heat is applied to the liquid in the hypsometer only once—when it's on the ground. After the liquid has been brought to a boil, the hypsometer is sent on its way, and the liquid continues to boil even though no other heat is applied. This is because the boiling point lowers as the hypsometer rises and, even though the liquid gets cooler and cooler, it remains at its boiling point for higher altitudes.

Although the temperature of the boiling liquid itself is an indication of altitude, the temperature of the steam given off by the liquid is a more accurate index.

In tests made with water, the hypsometer has continued to function even after the water has frozen, by taking the temperature of the minute quantities of vapor given off by the ice.

Peregrinating Pendulum

In 1860 Jules A. Lissajous, French physicist, produced optically fleeting images of compound motions on a screen. The odd patterns shown here and on the Frontispiece are *permanent* records of compound motions, made photographically by Arthur Palme. They were produced—in a photographic darkroom illuminated by a faint, dark red light—by a compound pendulum, the bob of which had fastened to its underside an automobile headlight bulb. The bulb was completely shielded with a metal cone, except for a 1/100-in.-diameter hole at the apex of the cone, through which a powerful but extremely fine and sharp beam of light emerged downward from the bob.

The length of the pendulum suspension was such that, when a piece of 11 × 14-in. bromide paper was laid on the floor, the apex of the cone came within about 1/8 in. above the paper surface. At rest, the bob was above the center of the paper. To start a pattern, the pendulum was swung to one corner of the bromide paper and was then released. The switch energizing the lamp was then closed, and the pendulum was left swinging from three to five minutes. The paper was then developed in the usual way.

The physics of this fascinating experiment are the simple basic laws of the pendulum. If a pendulum is suspended from two fixed points and the two suspensions are made to join further down in a node, from which continues a single suspension down to the bob—just like the capital letter Y—a compound pendulum is formed. Its bob will try to obey the $\sqrt{\text{length}/g}$ law with the length l equal to the stem of the Y (as in the accompanying diagram) and *at the same time* with the length L equal to the total length of the Y. This it cannot do in the usual one-plane swing of a pendulum; to satisfy both requirements, it will have to go out of its plane swinging, in a sort of "dance."

If the ratio of l to L is an exactly rational figure, patterns of perfect and steady resonance, or synchronism, will result. If that ratio is irrational, an unsteady and asynchronous pattern will be produced. When the node is located near a point of perfect resonance, the performance of the pendulum is extremely sensitive to change in ratio. For example, a relocation of the node point by 1/64 in. in a total length of

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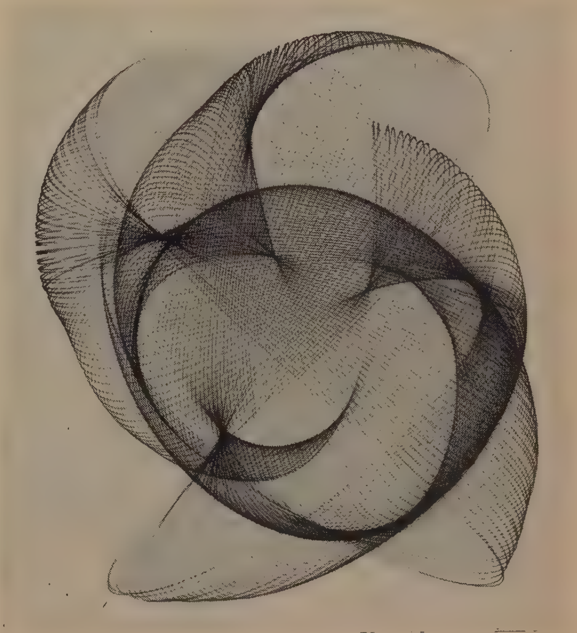
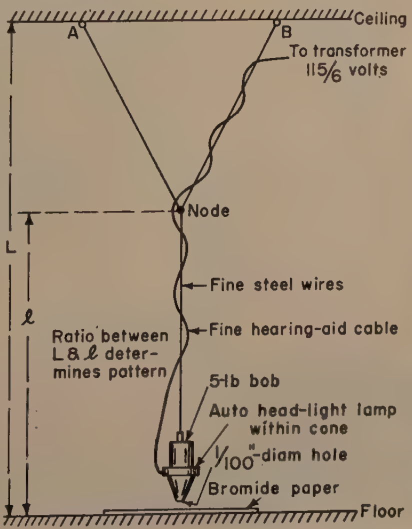


One of the countless variations in design obtained by slowly rotating the bromide paper beneath the swinging pendulum

(Below, left) Diagram of the compound pendulum and the light source

(Below, right) The pendulum about to be released at one corner of the bromide paper to start a pattern


Ceiling
A
B
To transformer 115/6 volts
Node
L
ℓ
Fine steel wires
Fine hearing-aid cable
Ratio between L & ℓ determines pattern
5-lb bob
Auto head-light lamp within cone
1/100"-diam hole
Bromide paper
Floor

HIGH LIGHTS & SIDE LIGHTS

(Continued from preceding page)

suspension of 108 in. (about one in 7000) will give patterns as much different as those at the bottom center and bottom right of the Frontispiece.

An endless number of patterns, no two of them alike, can thus be obtained. Additional and novel variations, like that on the preceding page, can be obtained by very slowly rotating the bromide paper while the pendulum swings above it.

Mobile Maintenance Shop for Circuit Breakers

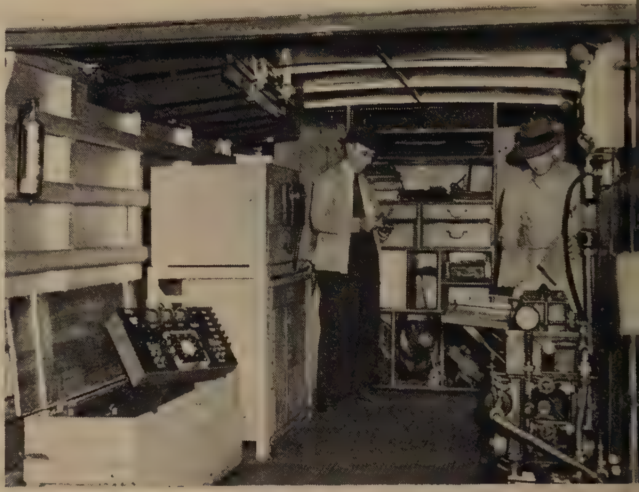
A specially equipped ton-and-a-half truck for circuit-breaker maintenance has recently been put into service by the city of Jacksonville (Fla.)

The maintenance truck is versatile enough to permit its three-man crew to work on any type of breaker. Mounted inside the truck are a 7-in. filter press and a four-compartment oven for drying filter-press paper. Also included are an oil tester for testing the dielectric strength of insulating oil, a synchronous timer, and two run-off reels providing 125 feet of three-conductor cable.

The truck furnishes either 110- or 220-volt single-phase service for operating the equipment. Light for night work is provided, as well as a battery light for emergencies. A three-kva 35,000-volt test set is available for high-potential tests on bushings and other breaker parts. The planned addition in the near future of a five-kva 110/220-volt single-phase portable generator, gasoline-engine-driven, will provide extra electric capacity for operation and testing of breakers and reclosing equipment and for extra night lights.

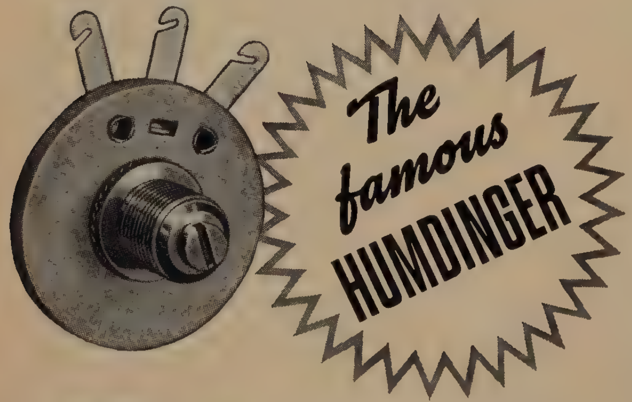
A hydraulic tailgate hoist, which receives its power from the truck motor, is used in handling magne-blast circuit breakers, making easier their remov from service for maintenance.

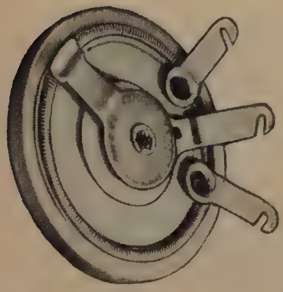
Hoses, stored under the truck rear, pe mit filtering the oil of apparatus locate as far as 40 feet away from the truc


Crew members at work inside truck for breaker maintenance

Two built-in oil tanks with a capacity o 60 gallons, a supply locker containin safety equipment, two ladders, and tw portable tool boxes make the truck a full equipped mobile maintenance shop.

The circuit-breaker-maintenance truc is used in conjunction with a similar uni for transformer maintenance.





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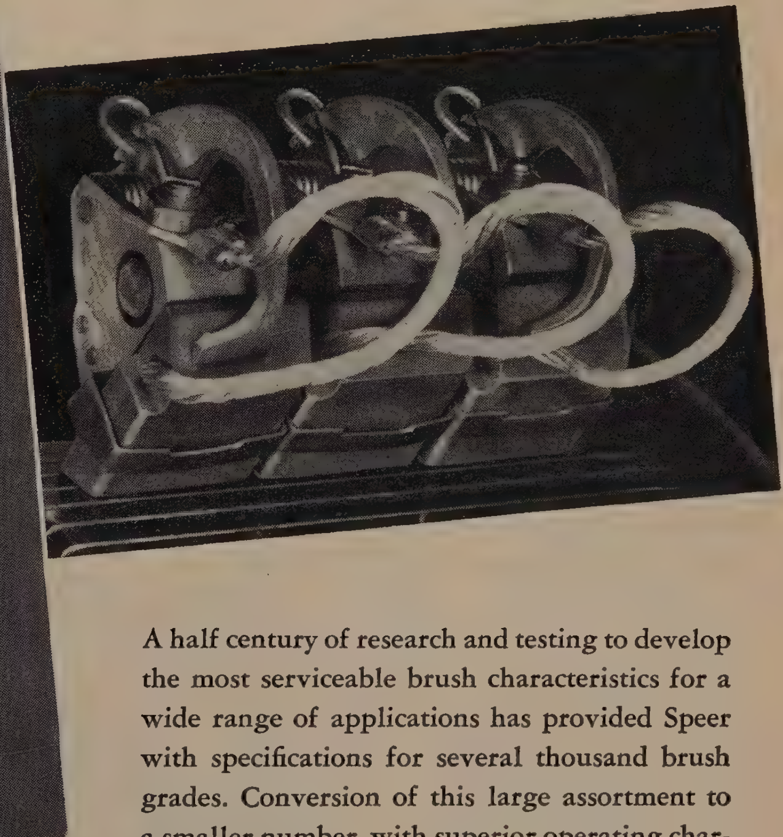

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NEW PRODUCTS: AND WHAT THEIR MAKERS HAVE TO SAY ABOUT THEM

Buffer Drum

A new type buffer drum, the Cone-Loc sander, designed to use standard strip abrasives. It is a split drum, cushioned with rubber, the halves of the drum being locked into a solid drum by a cone-type washer. Its light weight makes it highly adaptable for use with a flexible shaft as well as on a stationary arbor.

Standard width abrasives, available in roll form, are wrapped around the drum and secured into place by pins that recede out of the way when the cone washer is tightened. During buffing, polishing, or grinding operations the wheel never loses diameter and never needs dressing. Abrasive cloth in various grits can be quickly interchanged on the same drum to accommodate rough or fine work.—*American Diamond Saw Co., 519 N. W. Park Ave., Portland 9, Oregon.*

Terminal Blocks

The new solderless-type Bepco molded terminal block eliminates need for wrapping wires around studs or applying terminals to wire ends. These blocks are provided with compression-type solderless units, each capable of receiving wires from No. 16 to No. 6 AWG. Typical combinations which may be accommodated by a single terminal are two No. 10, two No. 12, or two No. 14; one No. 12 with one No. 10, one No. 12 with one No. 14, etc. Attachment of wires to block is accomplished by merely tightening screws after insertion of stripped wires. Rated 35 amp, 600 volts, the blocks are available in 4-, 8-, and 12-circuit sizes.—*Buchanan Electrical Products Corp., 1290 Central Ave., Hillside, N. J.*

Infrared Lamps

Two lamps have been added to a standard line of infrared lamps designed for industrial processing. One is a 500-watt globe-shaped lamp representing an increase of 125 watts over the previous most powerful lamp of this type. The other, equipped with a heat-resistant bulb, is a 375-watt lamp with a self-contained reflector. Chief advantage of the 500-watt lamp is its ability to increase infrared energy concentration on the job to be done in existing ovens designed for lower wattage lamps, and to hasten the processing of certain materials. Designed with a 5-in. light-center length, this lamp meets the requirements of open-reflector ovens.

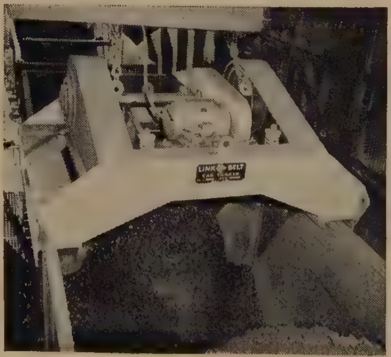
The heat-resistant glass bulb of the new 375-watt lamp minimizes breakage from splashing water or other liquids. It is designed to provide smooth distribution and high utilization of radiant energy.—*General Electric Co., Lamp Department, Nela Park, Cleveland.*

Pocket Chamber Electrometer

A new instrument for determining the amount of radiation to which pocket-pencil-type ionization chambers have been exposed, employing a true quartz-fiber electrometer, Model 4SN3A1, as the sensitive element. This electrometer is designed to read pocket-pencil-type chambers carried by personnel working in areas where radioactivity exists. Radiation values are indicated directly on a conventional $3\frac{1}{2}$ in. meter calibrated in milliroentgens. The unit operates on two separate ranges, 0 to 50 and 0 to 250 milliroentgens, each with a separate scale on the meter. By means of a photoelectric system using a servo principle, this new device is essentially a self-balancing electrostatic potentiometer.—*Specialty Division, General Electric Company, Electronics Park, Syracuse, N. Y.*

Car Shaker

A sturdy compact self-contained vibrating-type car shaker designed for rapid economical unloading of bulk granular materials from open-top hopper-bottom gondola cars to conventional hoppers serving bulk-materials conveying equipment. The shaker is of particular usefulness for unloading coal at central-station power plants, boiler houses, and retail coal yards; unloading sand, coke, ore, gravel, and cinders; and for accelerating the removal of damp materials frozen in cold weather. This equipment eliminates the destructive use of picks, augers, sledges, or air hammers to shake material loose; and its low-frequency vibration imparts no greater stresses to railroad cars than does their rolling along the road bed. The shaker, usually located at the center of the car, imparts equal vibration to both ends.—*Link-Belt Co., 300 West Pershing Rd., Chicago 9, Ill.*



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A new motor-operated fan for attachi
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move air over the indicator's wick in su
cient volume to permit obtaining stab
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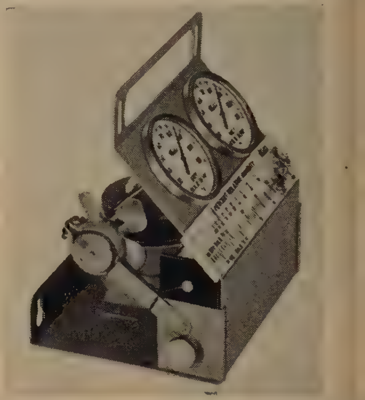
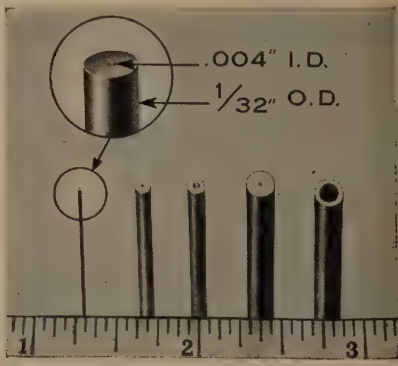
complete analysis of humidity conditions i
for example, a textile mill, particularly
and around the machinery while it is ope
ating, thus enabling the adjustment of th
humidifiers and air-conditioning equipme
for best results. No calculations are requir
because readings are immediately obtai
able on the instrument's simplified sli
rule.—*Weston Electrical Instrument Cor*
617 Frelinghuysen, Newark 5, N. J.



Extruded Shapes

Cemented carbide tubes as small
$\frac{1}{32}$ in. O.D. with an I.D. of 0.004 in., a
as large as $\frac{9}{16}$ in. O.D. with a wall thickne
of $\frac{1}{16}$ in. The O.D. is rough extruded 0.0
in. to 0.015 in. oversize, and the I.D. is he
to ±1 percent of specified size, and accurat
ly concentric. The ratio of I.D. to O.D. c
cover a wide range—either a relatively th
or thick wall.

These tubes can be supplied in either
two classes of Kennametal—one is straig
tungsten carbide, and the other is esse
tially titanium carbide. Both have hi
hardness, but the weight of the latter
much less and it withstands corrosion a
abrasion at elevated temperatures th
rapidly disintegrate cast alloys. The tu
sten carbide is suitable for parts subject
to abrasion at normal temperatures, su
as wire and thread guides, orifices, nozzl
punch and die parts, gauge elements, etc.
Kennametal Inc., Latrobe, Pa.



Recording-tape Splicer

A new device, the MT-1 Presto-Splicer, its and splices ¼-in. magnetic recording ape, permitting critical, efficient splicing ithout scraping, cementing, using adesives, or causing loss of tape. Applications t present include the fields of radio, audiongineering, and industrial and amateur lming, in television and Government work.

The operating principle is based on a comination of electrically produced heat and recise pressure, applied within an accuately controlled time cycle. Instead of eing held together by adhesives, a plastic eld is obtained, without adding to the hickness of the tape or using any of the ape material for the weld. Properties of the ape are not affected, and the splice is inudible even with playback amplifier at aximum gain. The splicer can be used for ddition of sound as well as deletion, and ape salvaged from editing can be spliced gain, erased, and reused.—*Prestoseal Manuacturing Corp., 38-01 Queens Blvd., Long sland City, New York.*

Capacitors

A new line of Pyranol filled capacitors, pecially adapted for oil-field service but qually usable in industrial plants. The apacitor, suitable for outdoor service, can e mounted in any position and is available n ratings of 2, 3, 4, 5, and 6 kvar at 460 olts. Each unit has a 4-ft length of flexible lamenol cable, including ground wires, ith a ¾ in. watertight connector at the nd of the cable for knockout connection o the motor starter. If a conduit installaion is desired, the connection fitting on he capacitor case can be removed easily nd a standard conduit fitting substituted.

These capacitors also can be used adantageously in existing electrified fields here the voltage level must be improved, here more wells must be served from xisting fully loaded substations, or where arger motors are required for pumping acks.—*General Electric Company, Maerials Industry Division, Schenectady 5, . Y.*

Microammeter

The electronic microammeter, Type 100, a new instrument designed for measuring ery small direct currents. The instrument as an input resistance of 50 ohms and a ensitivity of one microampere full scale. he input can be overloaded by currents as igh as ¼ amp without damage to the strument.

In operation, the instrument combines e characteristics of a magnetic amplifier ith those of a vacuum-tube output circuit provide low input resistance, high sentivity, and input overload safety.—*W. S. acDonald Co., Inc., 33 University Road, ambridge 38, Mass.*

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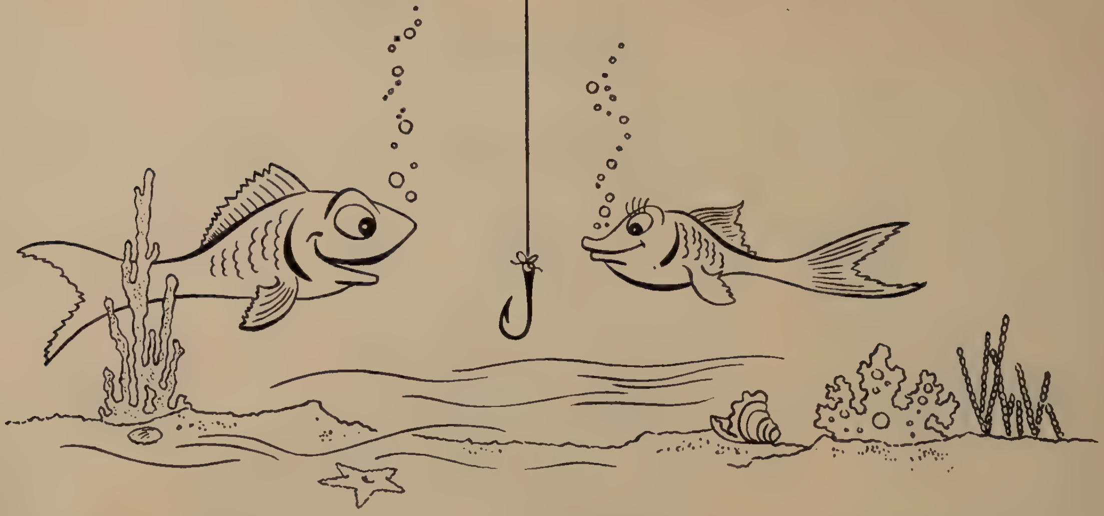
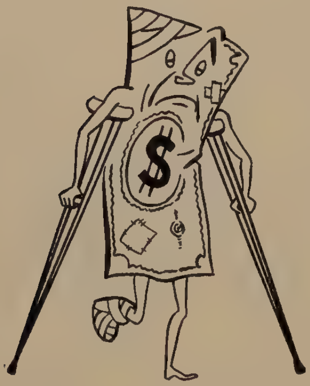


No Profit.....No Business



Fish won't bite where there is no bait. Business can't last where there is no profit.

The parallel is simple. It's bait that tempts the fish to risk the danger of the hook. It's profit that prompts the investor to take a chance and start a business.

It's profit that encourages the factory owner to enlarge his plant. It's profit that enables the employer to hire more workers. It's profit that keeps wages at high levels.

Anybody who attempts to persuade you that profit is wrong is up to no good—for you.

For, if the time ever comes when profits are taxed out of existence—and it can happen—then we will all be at the mercy of a state-owned, state-controlled, state-dictated economy.

In short, without profit, free enterprise must give way to slavery.

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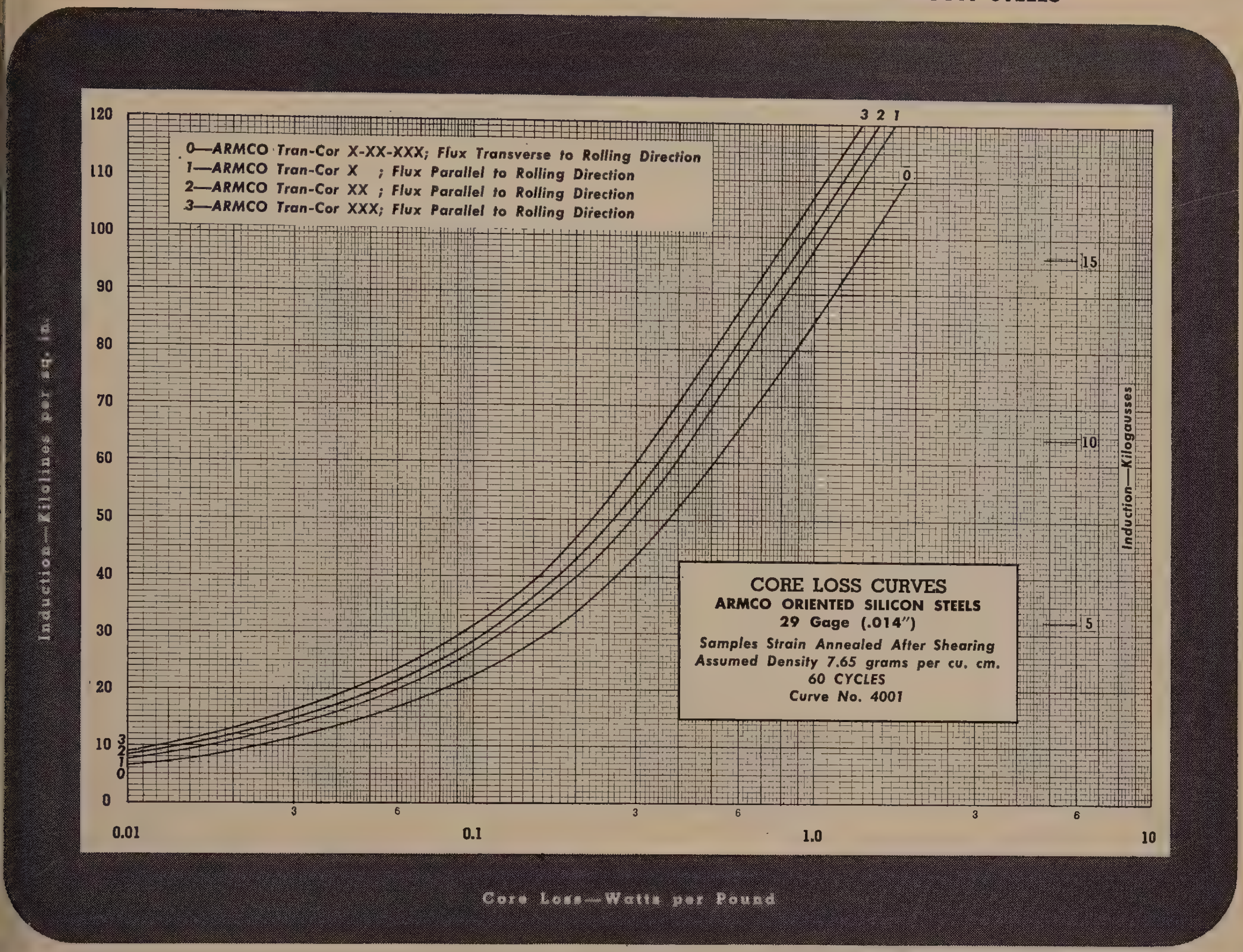

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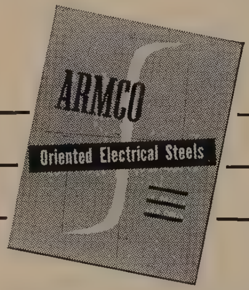
The high permeability of Armco Oriented Steels is fully utilized in wound cores, where the magnetic flux is parallel to rolling direction of the sheet or coil. In stacked cores, any flux passage not in the rolling direction should be limited to small sections.

Magnetic qualities of these grades are fully developed at the mill by a special high-temperature heat treatment. However, it usually is advisable to give the laminations or wound cores a moderate-temperature stress-relieving anneal after fabricating.

If a study of the core loss chart on this page interests you, write us for the booklet titled, "ARMCO Oriented Electrical Steels." With the data in this booklet, you can determine suitable shapes and dimensions for wound cores of highest efficiency. Just write Armco Steel Corporation, 3359 Curtis Street, Middletown, Ohio.



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AIR HEATERS—This booklet, functionally printed in four colors, is illustrated with flow charts, cross-section drawings, typical applications, and operating data that not only simplify the definition and understanding of direct-fired air heaters but clarify their applications as well. Six pages. Bulletin No. 600.—*Peabody Engineering Corp., 580 Fifth Ave., New York 19, N. Y.*

CABLE—The questions "What is aerial cable?" and "Where should it be used?" are answered in detail, but the greater portion of the bulletin is devoted to technical instructions concerning selection and installation of aerial cable, and instructions on splicing and terminating. Twenty-six pages. GEA-5157.—*Advertising and Sales Promotion Division, Construction Materials Dept., General Electric Co., Bridgeport 2, Conn.*

ELECTRICAL CONTACTS—Titled "Fastell for Heavy-duty Electrical Contacts," this booklet written in popular style describes properties and applications for Fastell, and embodies diagrams, photomicrographs, and data useful to all design and product engineers. Twelve pages. Technical Data Bulletin 7.101.—*Fansteel Metallurgical Corp., North Chicago, Illinois.*

ELECTRIC CONTROL DEVICES—Describes and illustrates rheostats, resistors, relays, motor starters, contactors, control accessories, and dimmers for use in industrial and commercial control applications. Eight pages. Bulletin No. 100,000.—*Ward Leonard Electric Co., Mt. Vernon, N. Y.*

INSULATION RESISTANCE TESTER—Practical suggestions given for selecting Megger insulation and resistance testers, together with a detailed selection chart, aid in making the correct choice for specific requirements a simple procedure. Eight pages. Bulletin 21-05-16.—*James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.*

MOTORS—Synchronous motors and instrument movements are covered in a catalog containing practical and technical data, a cutaway view showing construction features, and a Selection Guide Chart giving specifications and typical applications for light-, medium-, and heavy-duty motors. Eight pages.—*Telechron Inc., Ashland, Mass.*

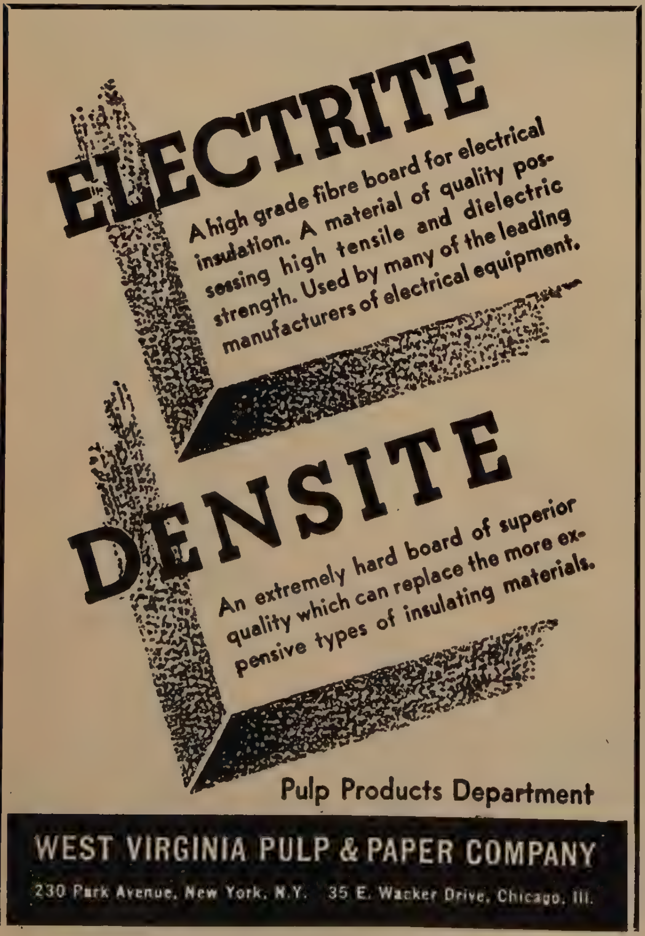
STEEL CASTINGS—A beautifully designed booklet directing attention to the versatility, strength, and dependability of steel castings, past performance record, research program, and future trends. Word-and-picture descriptions show use of steel castings for solving specific problems and meeting critical requirements of various basic industries. An insert tabulation of general engineering types of steel castings is classified according to tensile strengths. Thirty-four pages. Titled "The Steel Castings Industry."—*Steel Founders' Society of America, 920 Midland Bldg., Cleveland 15, Ohio.*

SWITCHES—Fuse-puller switches to be used as residential panels for main, range, and lighting circuit protection with terminals for water-heater connection are described. Contains circuit diagrams and illustrations of both flush- and surface-type switches. Four pages. Folder TEC 311A.—*Trumbull Electric Manufacturing Co., Plainville, Conn.*

TUBULAR HEATERS—Directions for formi and how to cast-in Calrod tubular heate are given in the text which is supplemente by photographs, drawings, sketches, an cutaway views. Eight pages. GEA-3391A.—*General Electric Co., Apparatus Dept Schenectady 5, N. Y.*

TURRET LATHES—The No. 2-H turre lathe which was discontinued during Worl War II is again available. The present ve sion has many refinements and added fea tures all of which are described in a ne illustrated folder. Eight pages. Catalo No. 67-F.—*South Bend Lathe Works, 42 East Madison St., South Bend 22, Ind.*

WELDING—After four years of intensiv effort a booklet of standard welding term nology has been completed containing mor than 500 terms and 57 illustrations. Prope distinction is made between closely relate concepts, and basic terms are so define that they are equally applicable to all welding processes. Fifty pages. Titled "Standar Welding Terms and Their Definitions, price $1.00. A chart lists the 37 weldin processes in commercial use today, an four additional charts compare these proc esses on the basis of similarities and dif ferences of 24 fundamental characteristic Set of charts titled "Master Chart of Welding Processes" and "Process Charts." Pric 35¢. Book of terms and charts purchase together $1.25.—*American Welding Societ 33 West 39 St., New York 18, N. Y.*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BOOK REVIEWS

(Available books may be purchased through the GENERAL ELECTRIC REVIEW for domestic delivery; none sent on approval.)

NDUSTRIAL ELECTRONICS AND CONTROL

Royce Gerald Kloeffler—John Wiley & Sons, New York. 1949. xiv + 478 pp. $5.50.

Mr. Kloeffler's work is a well-balanced extbook that deals with all known phases of he industrial application of electronic tubes. He is to be complimented on the fact that e stayed with the subject and did not leal with any strictly communication subects. The book is very easy reading and, lthough not highly technical, is quite horough.

The first half of the book is devoted to undamentals, including both tubes and asic circuits. Both vacuum and gas-filled tubes are covered in general, and complete data and operating information is given on many typical tubes. One chapter covers twenty different basic circuits and circuit components. The component description covers such items as peaking transformers, saturable reactors, selsyns, and amplidynes. The chapter on rectifiers is not as complete or as thorough as other sections of the book, considering the importance of this subject to a thorough understanding of industrial electronics.

The last half of the book describes in considerable detail many of the more important applications, including resistance welding, motor control, photoelectric applications, electrostatic precipitation, and high-frequency heating. This book can be highly recommended to anyone desiring complete general information on the subject.

HARRY L. PALMER

INDENTATION HARDNESS TESTING

Vincent E. Lysaght—Reinhold Publishing Corp., New York. 1949. xi + 288 pp. $5.50.

The metallurgist often wonders how the ardness-testing business arrived at its present state of development. The casual bserver is confused by the number of types of hardness tests and the great differences etween them. This author does a valuable ervice in briefly acquainting the reader with the history of the various tests.

The chapter on microhardness testing of netals does not appear to be completely satisfactory to the metallographer. The eviewer has seen photomicrographs wherein wo or three individual microhardness ndentations have been made in a single arbide particle. The author does not dwell ufficiently on microhardness testing to so ine a scale.

The author details the practical considrations surrounding the making of proper ardness tests, gives the reader an unbiased iew of the advantages and disadvantages f such tests, and delves into the theory as vell, in a concise and interesting style. For his reason, reading this book would seem o be a must for a hardness-testing techician.

W. A. REICH

ERSONNEL SELECTION: TEST AND MEASREMENT TECHNIQUES

obert L. Thorndike—John Wiley & Sons, nc., New York. 1949. viii + 358 pp. $4.00.

Dr. Thorndike's book is of interest to sychologists and to students dealing with echnical problems of testing and selection.

Executives and managers vitally intersted in testing as a personnel tool will also nd the book worthwhile, particularly the discussion of such topics as Administrative Problems in Using the Results of a Testing Program, and The Personnel Selection Program and the Public.

In broad outline this book follows conventional test and measurement techniques. A testing program begins with job analysis. Initial steps consist of a description of the job, followed by an analysis to determine the behavioral components of the job. In terms of such analyses, a preliminary selection of tests is made covering the significant components of the job. Following the estimation of the reliability of the tests, a determination is made of test validity in terms of criteria of proficiency. Techniques for combining individual tests in a battery, and methods for analysis and selection of test items are presented.

This book may well serve as a check list for the person charged with the responsibility of handling the administration and technical phases of a testing program.

The author draws heavily on experiences gained in the service of the Army Air Force during World War II. However, the discussion is not confined to the Army Air Force Program. Most of the procedures outlined are applicable to industrial testing and to testing on a smaller scale than that of the Air Force.

It may be worth pointing out that many mistakes have been made and probably are still being made in industrial testing because the criteria for a successful program as outlined in Dr. Thorndike's book have not been adhered to.

W. C. SCHWARZBEK

NUCLEAR FORCES: SECTION II

L. Rosenfeld—Interscience Publishers, Inc., New York. 1949. 363 pp. $7.50.

The publication of Section II of *Nuclear Forces* marks the completion of a valuable addition to the literature on nuclear physics. The two volumes of this monograph must be used as a unit, since the index, bibliography, tables, and corrigenda are included in Section II, and frequent reference is made in Section II to specific results presented in Section I.

The first volume contains a study of the general features of nuclear forces and a careful treatment of the neutron-proton and proton-proton systems. The second volume is devoted to a consideration of the various models used to describe complicated nuclei, and to a study of the influence of noncentral forces on nuclear properties. In addition, appendices are included on the theory of beta decay, nuclear moments, and the strong coupling approximation. The very important recent advances in nuclear physics which could not be included in the body of the text are outlined in the addenda.

Nuclear Forces (Section II in particular) is by no means easy reading for one not fairly familiar with theoretical nuclear physics. To a considerable extent this is due to the complicated and incomplete nature of the subject matter. Rosenfeld's treatise is of principal value to those who are interested in doing research in nuclear physics and wish a comprehensive survey of the physical ideas and mathematical methods that have been employed in the study of nuclear properties. This study is well suited to that purpose, despite the fact that rapid progress in the field has already made it partially out of date.

HENRY HURWITZ, JR.

The Electric-Lamp Industry

Arthur A. Bright, Jr.

This book is MUCH MORE than a complete, fascinating history of the electric-lamp industry, 1800-1947. That in itself is a story of daring enterprise, expansion, and competition. The BIG achievement of the book is to show clearly what encourages, conditions, or discourages invention and growth in any industry—such factors as cartelization, the patent system, tariffs, anti-trust legislation, etc. It will aid every interested reader to form a picture of what industry needs to keep pace in our century.

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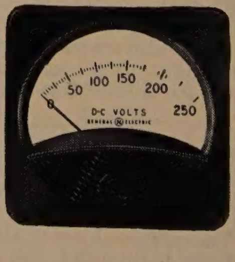

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Digest

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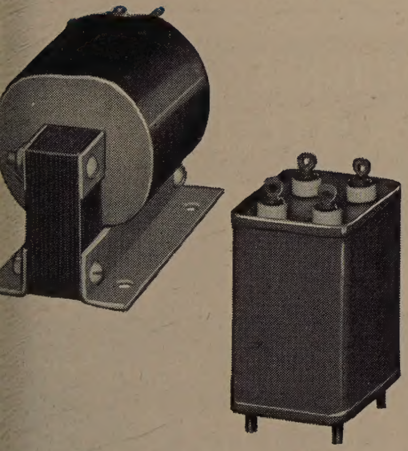

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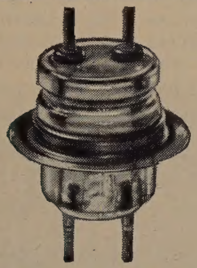

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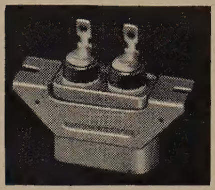

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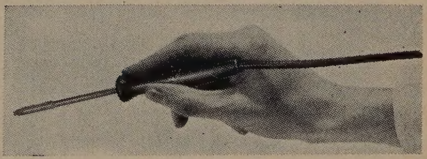

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ON ARTICLES IN OTHER TECHNICAL JOURNALS

AVIATION

High-speed Designs Need Simple Cockpits, by G. H. Hoover. *Aviation Week*, May 23, 1949; v. 50, pp. 20-22, 24, 26.

On the problems of instrument equipment for airplanes operating at very high speeds, taking into account the increased demands on the pilot's mental and physical capacities.

Vibration Testing of Airplanes, by Abner R. Willson. *Electronics*, Mar. 1949; v. 22, pp. 86-91.

Vibration pickups for airplane testing. Includes table of resonant frequencies at various points in a typical large plane.

CORROSION

Co-operative Approach to Electrolysis Problems, by Russell M. Lawall. *Corrosion*, Mar. 1949; v. 5, pp. 79-85.

An account of electrolytic-corrosion studies on underground equipment in the Detroit area.

Do You Know About—Fretting Corrosion? by E. V. Albert. *Diesel Power*, Mar. 1949; v. 27, pp. 38-43.

Light is shed on a phenomenon which causes serious failures, particularly to anti-friction bearings, under conditions where this effect would not be expected.

What Causes Localized Corrosion? *Steel*, Mar. 14, 1949; v. 124, pp. 86-89, 128.

Considers metallurgical factors, surface roughness, differential strain, and several other causes.

ELECTRIC MOTORS

Precision Speed Control, by A. L. Holcomb. *Soc. Motion Pct. Engrs. Jour.*, May 1949; v. 52, pp. 561-570.

The electronic control of special types of fractional-horsepower motors, capable of maintaining motor speed within one part in 25,000 under voltage variations of plus or minus 20 per cent and load variations from zero to full load.

Synchronous Motors Require Multi-functional Controls, by R. R. Gobeli. *Elec. Mfg.*, Apr. 1949; v. 43, pp. 93-99, 172, etc.

Control problems made more complex by the dual nature of synchronous motors between starting and running, and by the two power sources involved.

HEATING

Floor Surface Temperature and Heat Output With Radiant Jobs, by Paul S. Park. *Heat Piping & Air Cond.*, Mar. 1949; v. 21, pp. 74-78.

Explains the disagreement between theoretical limits of 30 to 40 Btu per hr per sq ft of floor for radiant heating systems and the success being obtained with installations calculated to produce 60 to 100 Btu per hr per sq ft.

Heating Today's Industrial Plant, C. P. Stolberg. *Heat. & Vent.*, Mar. 194 v. 46, pp. 69-72.

Industrial heating systems in curre vogue are reviewed, with the autho own estimate of the advantages and d advantages of each.

INSULATION

Predicting Insulating Performance Statistical Analysis, by Graham Moses. *Elec. Mfg.*, Apr. 1949; v. 43, p 108-112, 200-201.

Practical, simple methods, applicable any stage of construction, that will fo cast performance of finished products tests to destruction on a few producti samples.

Testing Electrical-insulating Va nishes, by Herbert G. Steffens. *Am. S Nav. Engrs. Jour.*, May, 1949; v. 61, p 375-406.

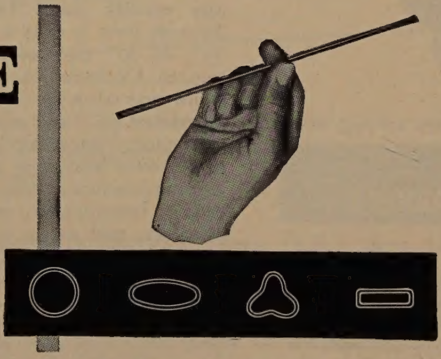
All types of tests of electrical-insulati varnishes are considered as to th methods, variables, and significance.

LIMITS AND TOLERANCES

Chance Laws Aid Designer in Assigni Tolerances, by Dorian Shainin. *Soc. Au Engrs. Jour.*, Mar. 1949; v. 57, pp. 24-26.

Shows how statistical methods can used to assign tolerances to the dime

(Concluded on page 5



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